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KNIFE WORK
IN THE
SCHOOL ROOM.

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KNIFE WORK

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IN THE

SCHOOL-ROOM.

BY

GEORGE B. KILBON.

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Preface to the Revised Edition.

THIS book is now for the first time presented to the public in the form of a suggested four years' course of manual training for grammar school pupils. The first edition, which was published a year ago, merely outlined the course for a single year and has been thoroughly revised for the complete work.

Since this edition appeared the author has been frequently asked by teachers and others who are interested in this work wherein the system which he advocates is better than the Swedish sloyd. His answer to this question is, in the first place, because all the problems suggested in this book can be readily worked out by the pupils while seated at their desks, whereas the sloyd system always requires a workshop separated from the ordinary schoolroom. Again, the sloyd work is confined to problems which result in making articles that are nominally useful, thereby excluding many that are of the greatest value from an educational standpoint. We should never think of putting a boy at work keeping a set of books for the sake of grounding him in the fundamental principles and practices of arithmetic, and how can we expect to educate him manually by limiting his work to "useful" things? Moreover, it is always an open question just how useful these Swedish models are, measured from American standards.

Sloyd problems were arranged in the infancy of manual training, when public suspicion of the value of the New Education made it seem necessary to teach the construction of articles of common use as a means of obtaining pupils. But at the present time the phrase manual training has assumed its rightful meaning, which is the cultivation of the hand for the performance of skilled labor, in general, rather than a given amount of practice in producing a variety of domestic articles. Throughout this book the effort has been made to regard the educational problems as of paramount importance.

Another reason why these problems should be preferred to the sloyd system is found in the fact that some of the sloyd tools are not used in joinery, or any other kind of American woodwork, while the pocket-knife, the chief instrument of this proposed course, is a tool of universal use, although hitherto it has been much abused. The author hopes that his book will do something to elevate the pocket-knife as a tool which in the hands of trained pupils is capable of fashioning articles of accurate shape and ornamental form, so that it may no longer be regarded merely as an instrument for mischievously marring furniture and casements.

As a final argument for this system it is proper to urge the simplicity and cheapness of the equipment and material required. The method of imparting manual training through educational problems was first illustrated in this country by an exhibit in the Russian department of the Centennial Exposition in 1876. Since then the system has been modified in certain particulars to meet American ideas and needs. This book is an attempt to present the elementary steps of what is now known as the American system of manual training in a practical form, with the least possible expense for outfit and material. Doubtless experience in applying this course in the schoolroom will create a demand for further modifications. But the scheme as a whole is offered in the belief that everything can be said in its favor which is urged in behalf of sloyd, and that it has additional educational advantages of very decided value, when compared with the Swedish methods.

SPRINGFIELD, MASS., August 1, 1891.

The Essence of Manual Training.

BY MILTON BRADLEY.

MANUAL Training may be said to belong to the vocabulary of household words in these latter days, so much is it discussed in public and private, from the platform and in the newspapers. Under such circumstances the question is a fair one, What do these words mean, and how are they related to public education? For it often happens that the very words which are most frequently in people's mouths are least understood by the long-suffering person known as "the general reader."

It seems eminently proper that a treatise on "Knife Work In the School-Room" should be preceded by a brief exposition of the principles of manual training as they are understood by the author and a few of his fellow citizens who for years have labored with him to build up what is known as the Springfield system. We may remark, at the outset, that the fundamental idea of manual training for the child is a very old one and is readily explained. It found sanction in the scriptural passage, "Train up a child in the way he should go, and when he is old he will not depart from it." That is, not only teach him how to study and think, but also to work with his fingers and thereby "make himself generally useful."

Led by such reason as this many successive generations of parents from the Jews of old to the present time have required that every boy should learn a trade. Why did the parents of Saul of Tarsus put him through a course of tent-making during his tender years, so long as they had the means to give him a "finished" education in Jer[illegible] the feet of the most distinguished Hebrew teacher of his day? Doubtless that he might have "something to fall back on." From his birth on there was always the chance that the gifted preacher would find it either necessary or desirable to labor with his "own hands" that he might "be chargeable to no man," precisely as he did at Corinth, the same liability that attaches itself to any man, be he ever so rich or learned.

This utilitarian notion of manual training for childhood and youth has a multitude of modern apostles. Some years ago Edward Everett Hale made a stirring speech to General Armstrong's colored boys at Hampton, Va., urging the advantages of learning the printer's trade, because he who has once mastered it can "set to" and earn a living in any clime, mending reverses which may have befallen him in other callings and traveling from country to country for instruction and amusement.

If manual training is so beneficial and really a necessary part of an education, from a utilitarian stand-point, why not introduce it in the public schools? "Teach the pupils to make things themselves; things which will be useful and which will be sold to admiring friends;" say the ardent advocates of this new application of an old idea.

These people, however, although they include a good many educators of note, labor under a serious misapprehension regarding the end of manual training as it is understood by the thoughtful promoters of the so-called New Education. Indeed, it can be safely said that manual training is everywhere suffering from the almost universal misconception on the part of the public that its end and aim is the teaching of trades, that it robs the pupil of certain hours which would otherwise be given to the common or higher branches for the sake of teaching him to "make things" which are supposed to belong solely to the carpenter's or blacksmith's shop. But manual training proper, considered in its educational relations, must be at once and for all time separated from the idea of immediate financial, or money getting results. In other words, manual training in the public schools must be kept clear and distinct from trades schools or the teaching of trades.

The mental education which we undertake to give our children at public cost is supposed to be equally valuable to the pupil whether he becomes a business man, manufacturer, lawyer, clergyman, physician or teacher. On the same principle the manual training which we are seeking to incorporate as a part of our public-school system is intended to benefit alike the future carpenter, machinist, blacksmith, manufacturer or general mechanical engineer; nay more, it is expected to help the boys who are to follow commercial or literary vocations just as much in rounding out their education and equipping them for life as it does the other class. For we can never "send the whole boy to school" till we give those who are destined for the mechanical class of the world's workers a fair mental training, and also impart to those who are to make up the professional class the fundamental ideas of hand culture. After this has been done we can well afford to leave technical education, whether it seeks to produce a lawyer, a plumber or an engineer, to the special schools.

Manual training is no new thing in our every-day American life. In the country districts fifty years ago the children had nine months of manual training of the best kind, because of the tasks required of them on the farm and in the shop and the kitchen. They also averaged three months of mental training, during which time they learned rapidly, in spite of the lack of ability on the part of their teachers. They had too much manual training and were hungry for the mental, consequently it did not hurt them to study night and day, through the two or three months that they were in school. Even now the boys and girls brought up in the country get something of this same training. During thirty years' experience as a manufacturer the writer has found that when the country boy is put at work in the shop he shows himself much more ingenius and "handy" than the boy, who, having been raised in the city, is theoretically in closer touch with the mechanical arts.

Owing to the changed conditions of society in all our cities the children who fill our schools have more mental education than they relish, and are hungry for any manual education which circumstances happen to throw within their reach. It is impossible for either the rich or the poor children to get this much-needed education at home, therefore the school is their only hope. Many parents are coming to realize this fact and to demand that manual training shall have a recognized place in the public-school course.

Because of certain favorable conditions and the well directed energy of a few people who combine with their professional ability as teachers a natural taste for mechanical pursuits Springfield has obtained a national reputation for her public-school work in manual training, as well as in all other directions.

When I speak of a national reputation I do not mean that our city is in advance of many others which might be named, but that, considering its size, an admirable start has been made along some lines which have been original. Long before this question of manual training had reached even its exprimental stage, outside of the largest cities, the subject was thoroughly studied and watched by a few of our people, who were intensely interested. Some of them had sufficient confidence in manual training as a practical educational scheme to invest their money in various experiments, but all of them counseled no action on the part of the city until certain principles could be better settled and understood. After some of the doubtful points had been tested by private experiment, here at home and in other cities, our school board decided to make a beginning, and from the time on there has been a continuous growth, with a very few, if any, serious mistakes. While in any line of progress the work must in its details be somewhat experimental, I maintain that manual training in general has passed its experimental stage. I claim that a complete and satisfactory course of manual work, from the first primary grade through the high school, has been laid out for our Springfield pupils by the school committee and fairly tested, and that this course can be duplicated with educational profit and at reasonable expense.

This whole course is planned to supplement the work of the kindergarten, which should precede it whenever possible, as the kindergarten training will prove a decided help to the pupil who undertakes such tasks as those described by Mr. Kilbon.

This book will explain itself. The knife course was first introduced into our grammar grades to give the boys something to do while the girls were taking their weekly sewing lesson. Mr. Kilbon as principal of the city manual training school, has spent a great deal of time and thought in undertaking to perfect it, thereby utilizing many years of experience as a draughtsman and superintendent of mechanical construction in a large manufactory.

SPRINGFIELD, MASS., July 1, 1890.

Knife Work In The Schoolroom.

BY GEORGE B. KILBON.

TO a person conversant with the development of Manual Training during the past few years, it is manifest that for children younger than six or seven years the gifts and occupations of the kindergarten furnish a series of manual lessons suited to their capacity. It is also manifest that the work of the "Manual Training School" or "Mechanic Arts School" is adapted to the capacity of pupils of thirteen or fourteen years and upward.

For those between the ages of seven and thirteen there is no satisfactory course of manual work arranged, and the object of this treatise is to make some suggestions that may help solve the difficulty.

Many of the problems herein described and designed for a four years' course in knife work have been experimentally tried in the Springfield schools, and the call from other places for a knowledge of what is being done in Springfield has led to their publication. They possess, without doubt, crudities which further experience will correct.

The Springfield grammar-school grades are numbered from one to nine; the age in grade one being five years and upward, while the age in grade nine is thirteen years and upward. The ninth or senior grade is provided with a general tool course for which pupils leave their buildings and go to the city manual training school. For pupils in grades below the fifth, exercises in clay modeling, paper cutting and folding are well adapted. It is for pupils in grades fifth to eighth, inclusive, that this course is intended, and the work is done in the ordinary schoolroom, while the children sit at their desks.

The following is an outline of the four years' course :—

Fifth Grade—Surface forms, cut from thin wood.

Sixth Grade—Part I, Carving. Part II, Surface forms, cut from thick wood.

Seventh Grade—Part I, Geometric solid forms. Part II, Joints.

Eighth Grade—Mechanical and natural forms.

The only cutting tool used is the knife.

For laying out the work a gauge, try-square, dividers, rule and pencil are used with the knife.

The cost per doz. of a good set of the above tools is as follows :—

Gauge,	$1.40	per doz.
Try-square,	2.00	" "
Rule, 12 in.,	.84	" "
Pencil, medium,	.25	" "
Dividers,	2.25	" "
Knife,	4.60	" "
Total,	$11.34	

Beside these a teacher needs for occasional use :—

One small pene hammer,	$0.35
One 10 in. back saw,	.75
One handle of brad awls,	.30
One pair pliars,	.35
One mounted oilstone,	.60
One oil can,	.30
Total,	$2.65

To protect the desk-top make a cover of ½ in. pine. Let this cover be 1 ¼ in. longer than the desk-top and 10 in. wide with cleats 1 in. x ½ in., nailed edgewise on the underside at both ends, and at the front edge.

The completed cover will then have ¼ in. play endwise, as it lies on the desk. The figure below gives three views of it, and its cost need not be over $2.40 per doz.

The total cost of equipment as described above for a class of twenty-four will be :—

2 doz. sets tools, ...	$22.68
2 doz. covers, ...	4.80
1 set tools for teachers, ...	2.65
Total, ...	$30.13

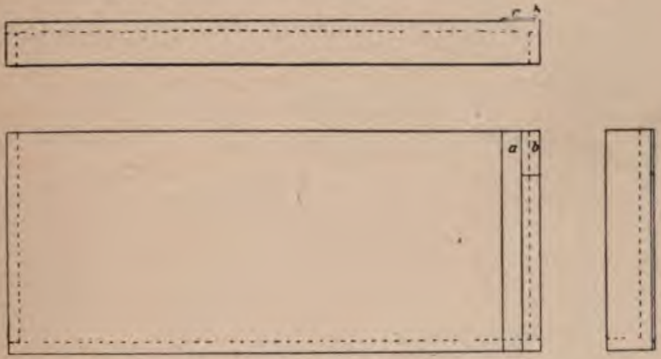


FIG. 1.

A convenient attachment to the cover for holding work during gauging lessons is as follows : Take one piece of $\frac{1}{8}$ in. bass or pine, 10 in. x 1 in. and one piece 2 in. x 1 in., and nail them on the cover, as shown at *a* and *b*, Fig. 1. These covers will be improved if some of the older pupils are allowed to stain them with burnt sienna, and then varnish them with two coats of shellac. The sienna should be made sufficiently thin with turpentine, put on with a brush, and rubbed with waste rags so that the grain of the wood will show through, as burnt sienna is a stain and not paint.

After the first coat of shellac is put on and allowed to dry an hour or more, sandpaper it enough to smooth down the grain of wood which its putting on has roughed up, and then add the finishing coat.

To hold one dozen sets of the pupils' tools, make a box of $\frac{1}{2}$ in. pine or whitewood, 3 in. deep inside, as shown in Fig. 2.

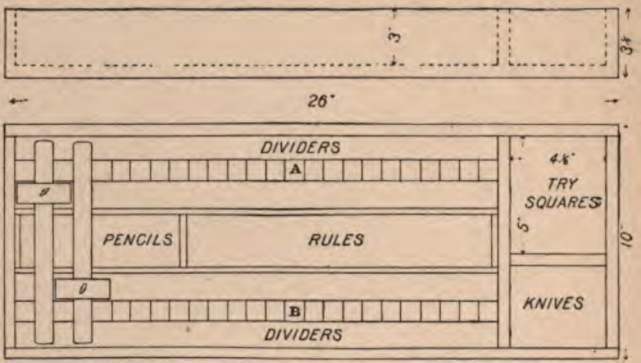


FIG. 2.

The outside dimensions are 26 in. x 10 in. x 3 $\frac{1}{2}$ in. A and B are strips of $\frac{7}{8}$ in. pine, notched to hold gauges, of which two are seen in position. See also Fig. 3 for an elevation of one of these strips.

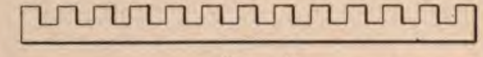


FIG. 3.

The rules, dividers and pencils can lie underneath the gauges in the spaces indicated in Fig. 2.

Each box with its cover should not cost over $1.00, and a box to contain the single set of teacher's tools 15 in. x 6 in. x 2 in., inside measure, 50 cents, making a total of $2.50.

Some grinding of the knives will be occasionally needed, but it would be better to pay an expert to do that, as few if any boys of nine years can be trusted to attempt it. Some janitors can do it, and in such case a treadle grindstone for $4.50 will be a good investment.

The above-mentioned expenses make a complete total of $37.13, which is all that is needed for one grammar building, as the pupils in any two different grades need not be working at the same time.

At the close of this manual will be found a series of plates, containing the problems of the course. The method of making any problem is minutely described in the lesson numbered to correspond with the number of the problem, with the exception of Lessons I and VI.

An effort has been made to have each problem clearly explained and illustrated in detail, in order that a novice in tool-using may become self-taught.

Problems 1 to 6 are performed on basswood 5-16 in. thick, machine finished to the required dimensions.

The object of furnishing prepared material for these problems is to give first lessons in accurate use of gauge and try-square; this of course requires accurate shapes of wood for use.

Prepared material is also used for all the carving problems and for most of the problems of the third and fourth year, thereby avoiding much tedious monotony and making the lessons more interesting.

Experience seems to have determined that basswood is best adapted to this course of work. It is uniform in texture without alternating hard and soft grains, it does not split too easily and is soft.

If basswood cannot conveniently be obtained, the whitewood of commerce, sometimes called poplar, (tulip tree), is not very difficult to work. Also a very soft grade of pine may be used to advantage, but a piece approaching the nature of yellow pine is very unsuitable.

In the southern states where the yellow pine is so universally used, there can occasionally be found a log of a reddish color seeming to be half dead, which is nearly as good as white pine.

FIRST YEAR.

FIFTH GRADE.

SURFACE FORMS,

CUT FROM THIN WOOD.

LESSON I.

GAUGE DRILL.

Supply each pupil with a gauge and teach to hold it as in Fig. 4. The thumb of left hand should be free to pass up and down the gauge-stick and in constant contact with the gauge-block, while the right hand loosens the set screw, moves the block up or down, and then tightens the screw.

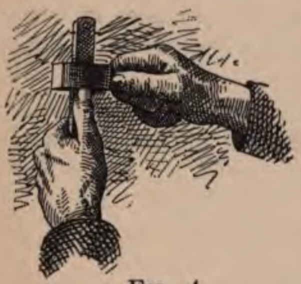


FIG. 4.

Drill class in unison at setting gauges on different graduations, until they are familiar with the graduations and agile at shifting the block. Begin with the coarse graduations, that is, inches and half-inches, and continue successively with quarter-inches, eighth-inches and lastly sixteenth-inches. An enthusiastic teacher will find ample variety to fill the time of the first lesson, which should not be over forty minutes.

LESSON II.

USE OF GAUGE.

Take for each pupil a piece of prepared material, 8 in. x 2 in. x 5-16 in. Teach to hold gauge, as in Figs. 5 and 6.

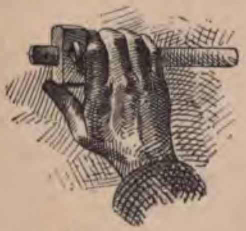


FIG. 5.

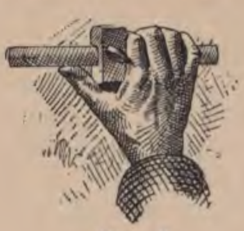


FIG. 6.

The first position, Fig. 5, is more convenient for narrow gauging, as $\frac{1}{8}$ in. to $\frac{3}{8}$ in.; the second position, Fig. 6, is necessary for wide gauging, as 3 in. or more.

The firmest hold is secured if the end of the thumb and the inner shoulder of the *little finger's knuckle* press against the front side of gauge-stick, while the middle bones of the three fingers and the end of little finger press the opposite side, thus forming a vice, the elbow meanwhile touching the body and the gauge-stick being held at right angles to the forearm.

Too much stress, however, should not be laid on the exact form of grasp, if the pupil accomplishes the important thing, the making of straight lines.

Set the gauge at $\frac{1}{2}$ in. graduation. Hold the wood by means of the left hand against the cleats prepared for that purpose at the right of desk-cover; hold the gauge as in Fig. 5, and make a straight line along the entire length. See Fig. 7.

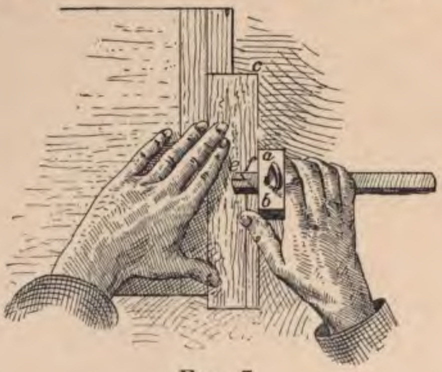


Fig. 7.

In doing this it is necessary to care for the three following points continually, and proficiency in gauging is acquired only when the power to guard against error at any one of these points becomes instinctive: I. The face *a b* of the gauge-block *must* be kept through its entire length in uninterrupted contact with the edge, *c d*, of the board. II. The farther lower corner of that portion of the gauge-stick, *e f*, which projects beyond the gauge-block *must* be in complete contact with the board. See *a*, Fig. 8. III. The gauge *must* be rolled on the axis of the stick, in the direction of the arrow, Fig. 8, until the point enters the wood, as in Fig. 8. It is manifest that if held as in Fig. 9 no line will be made, and if held as in Fig. 10 a very deep line will result. A little care in the amount of rolling between the two positions shown in Fig. 8 and Fig. 10 will enable a skillful workman to make any depth of line required, and it is good discipline to drill a class in making the two different lines, fine and medium. The medium line is the important one for pupils to master. When one line is gauged, the process of making which is shown in Fig. 7, turn the board around and make another. The face of the board will then present the appearance of Fig. 11, if the work has been well done.

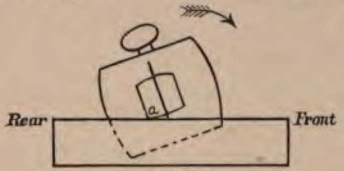


FIG. 8.

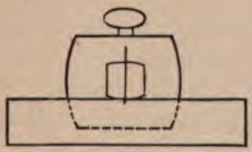


FIG. 9.

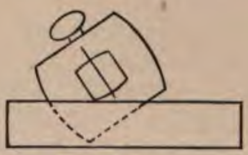


FIG. 10.

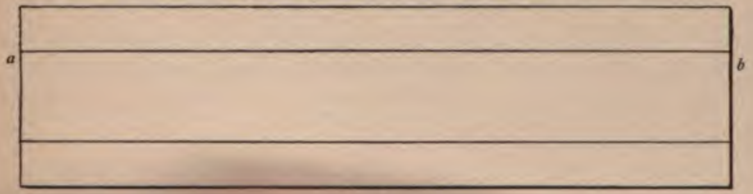


FIG. 11.

Turn the board over and make two corresponding lines on the other side. Four lines have now been made, with gauge set at ½ in. Set gauge at 7-16 in. and make four lines in the same manner; so continue setting the gauge 1-16 in. less successively and make four lines at every setting, until 1-16 in. setting is reached. The board will then appear as in Fig. 12, or Problem 1, Plate I.

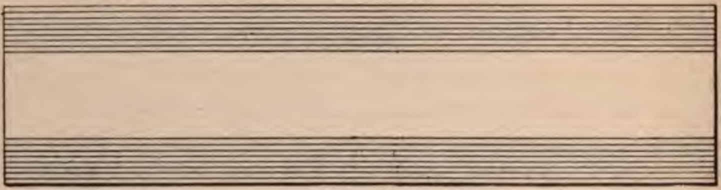


FIG. 12.

Have each pupil write his name plainly and neatly on one side of the board. The name should be written on every finished problem. To perform Problem 2, repeat Problem 1 and fill both sides of the board with lines 1-16 in. apart. Problem 1, will then show the pupil's first effort and Problem 2, his proficiency. The name should be written on Problem 2, before gauging.

The object of making many lines on a small piece of wood is to give the most instruction with the smallest amount of expense for material. Allow rapid workmen to repeat these problems with a second set of boards.

LESSON III.

MEASUREMENT.

Take a board 8 in. x 2 in. x 5-16 in., and on one side of it gauge one line 5-16 in. from each edge, one line ⅝ in. from each edge and one line in the middle. It will then appear as in Fig. 13.

Place the rule along the line *a b*, one end exactly coinciding with the end of the board, and with the knife make points on the line *a b* against every ½ in. graduation of the rule. Hold the knife as in Fig. 14. It must not incline to the right or left, but should incline away from the workman at an angle of about 30°.

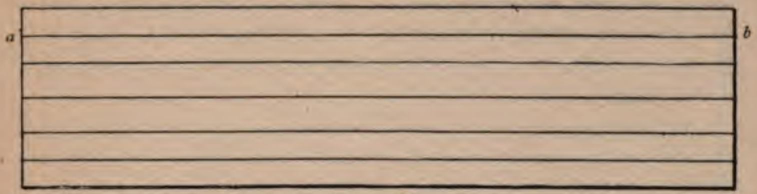


Fig. 13.

Do not draw lines with the knife, but simply push it vertically, sufficiently hard to make a deep cut that can easily be seen when sitting erect. It is important that pupils learn to make these points of right depth and that they do not make lines instead of points.

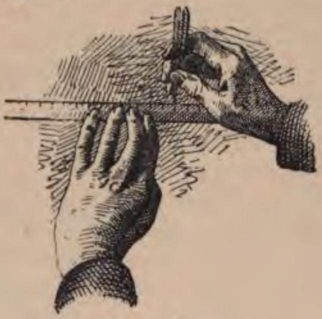


Fig. 14.

Next lay the rule along the line below the line $a\ b$, and make points against quarter-inches; then along the next line, making points against the eighth-inches; then along the next line, making points against the sixteenth-inches. The remaining line may be used to give class drill in varying measurements, at the teacher's dictation. See Problem 3, Plate I. The drawings on this plate are made about half size and the lines on Problem 3 are graduated thereon, as stated above, viz: On the upper line measurements at every ½ in.; on the second line at every ¼ in[illegible] on the the third line at every ⅛ in.; on the fourth line at [illegible] 1-1[illegible]. The measurements on the lower line, beginning at the left, are successively 1 in., ½ in., ¼ in., ⅛ in., 1-16 in., ⅛ in., ¼ in., ½ in., 1 in., amounting to 3 and 13-16 in., the measurements on the lower line beginning from the right are successively, 10-16 in., 9-16 in., 8-16 in., 7-16 in., 6-16 in., 5-16 in., 4-16 in., 3-16 in., 2-16 in., 1-16 in., amounting to 3 and 7-16 in.

The back of the board may be gauged like the front and varying measurements at the teacher's dictation laid out on the lines. Let the sum of any one series of these varying measurements be less than four inches, and at the close of each series see how many pupils have advanced to the correct amount.

LESSON IV.

USE OF TRY-SQUARE.

Fig. 15 is a perspective view of a try-square. The try-square consists of two parts, the beam and the blade.

Its use is to enable a workman to draw a line across a board with a pencil, scratchawl, or knife, exactly at right angles to the edge of the board. To do this the blade *must* be held firmly against the face of the board, while the beam must be held firmly against its edge. Let the forefinger of the left hand hold the blade to the face of the board, while the thumb and remaining three fingers hold the beam against its edge. See Fig. 16.

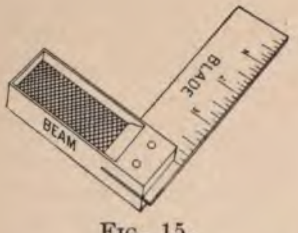


Fig. 15.

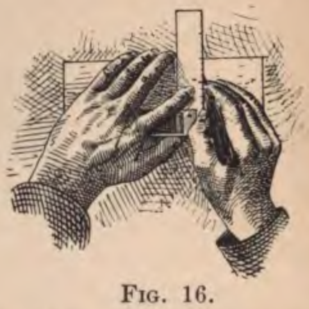


Fig. 16.

To perform Problem 4, Plate I, take a board 8 in. x 2 in.

x 5-16 in., and with rule and finely-pointed pencil lay off every inch along the length of the board, as in Fig. 17.

Put the square on as in Fig. 16, place the pencil carefully on the first right-hand point, carefully move the square against it, take up the pencil and with it draw a line across the broad face or side of board, close to the blade of the square. Do not make a heavy line, as it will destroy the pencil point, and draw the pencil but once. Turn the board one-quarter of a revolution away from you, hold the blade of the square on the edge of the board thus brought uppermost, and draw a line across this edge, exactly joining the line previously made on what is now the back side of the board. Continue this process of turning the board and squaring across the remaining side and remaining edge until the line has been squared entirely around the board when it should exactly meet its starting point. The board will then present the appearance of Fig. 18.

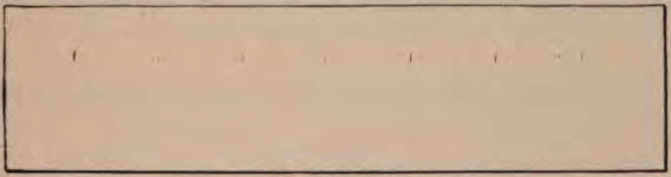


FIG. 17.

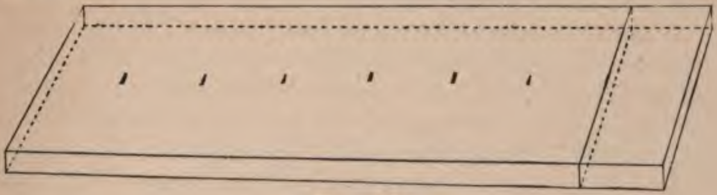


FIG. 18.

Repeat this process, squaring lines around the board, through each of the remaining points, *using the pencil, drawing it lightly*, drawing no line more than once, and inclining the pencil slightly to the right, so that its point shall be sure to press against the blade. This inclination of the pencil away from the square blade should bring that side of the cone of sharpening, which is next to the square blade, perpendicular to the face of the board.

When lines have been squared through all points except the three nearest to the left end of board, turn the board end for end, that is, so that the end which has hitherto been at the left, shall be at the right, and square through the remaining three points. The reason of this turning is obvious, the beam of the try-square will otherwise have too small a bearing against the board.

Lay the rule again upon the board, and with the knife held as in measurement, make points at the half-inches. Square around the board through each of these points with the knife, precisely as has just been done with pencil, except that the knife must be lightly drawn once so as not to move the square from its position, and then redrawn somewhat heavier, so as to make a line of sufficient working depth. It may be necessary sometimes to draw the knife through a third time, as the line must be of a working depth, so that a knife blade scraping along lengthwise of the surface of the board will be instantly and easily arrested when it enters the line.

It is obvious, also, that the try-square must not be moved by reason of pushing the knife against it with more force than the left hand exerts to hold the square in place.

When a line has been squared across one side and the board turned away from you, bringing an edge uppermost, put the *extreme point of the knife* on the corner and exactly in the line previously made, and draw the line as before. Success cannot be attained without this caution regarding the knife-point. Continue this line on the remaining side and edge until it joins its starting point. Through the remaining $\frac{1}{2}$ in. points square in like manner.

Lay the rule on once more, with the knife make points at the quarter-inches, and square around the board through them. The last lines, through the quarter-inch points, should show improvement over the lines first made. The completed work will appear as in Problem 4, Plate I. Greater proficiency will be gained if the problem is repeated. Supply each member of the class with a new board for that purpose.

LESSON V.

TRY-SQUARE AND GAUGE COMBINED.

Take a prepared piece 4 in. x 2 in. x 5-16 in. Lay the rule upon it, as in Fig. 19 and, with the knife held as in measurement lesson, make points at every eighth-inch until six points have been made from each end of the board. The board will then appear as in Fig. 20.

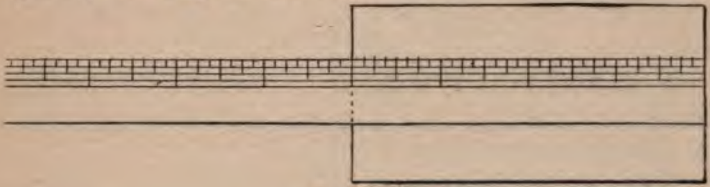


FIG. 19.

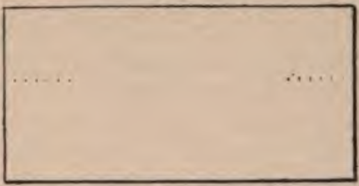


FIG. 20.

Through the first point at each end square a line across the face of the board.

Set the gauge $\frac{1}{8}$ in. and gauge a line *from* each edge *on* this face, starting and stopping at the above squared lines. The board will then appear as in Fig. 21.

The object of this lesson is an additional step in gauging, viz., to start and stop on lines. Proceed in the same manner with the remaining five points, making every gauge line and every knife line of a p[illegible] working depth, as has been previ[illegible]ly described. and [illegible]s to always start and stop exactly on lines. When finished the work will appear as in Problem 5, Plate I, the open space in center is left for the name.

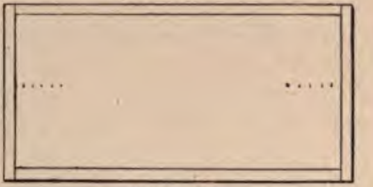


Fig. 21.

Problem 6, Plate I, is similar to Problem 5, the difference being that in this problem diagonals are first drawn and that the points for squaring are $\frac{1}{4}$ in. apart.

Notice that all lines parallel with the grain or fiber have been made with the gauge and that all lines across the grain have been made with the knife. With rare exceptions this will be the universal rule. Problem 6 is for pupils who work rapidly.

LESSON VI.

GAUGING ON EDGE AND END OF BOARDS.

Every board has two sides, two edges and two ends. See Fig. 22.

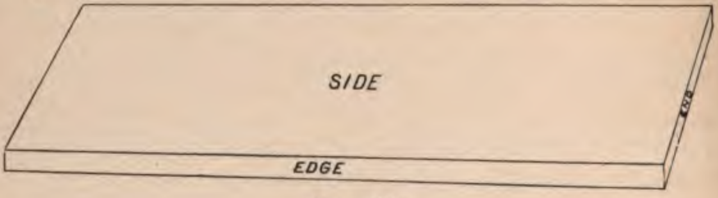


Fig. 22.

Any one of these six is called a face when it is planed true. The expression to gauge *on* any given face means that the gauge point cuts a line on that face; the expression to gauge *from* any given face means that the gauge-block slides in contact with that face. The work of the present lesson is to gauge *on* the edges and ends of all the boards thus far used.

Set the gauge at 1-16 in., take the first board used in Lesson II and gauge *on* its edges and ends *from* both of its sides; set the gauge at $\frac{1}{8}$ in., and repeat. This practice is an additional step in gauging, and is more difficult than the previous gauging lessons. When this first board has the four lines thus gauged around on both of its edges and ends, it will appear as in Fig. 23.

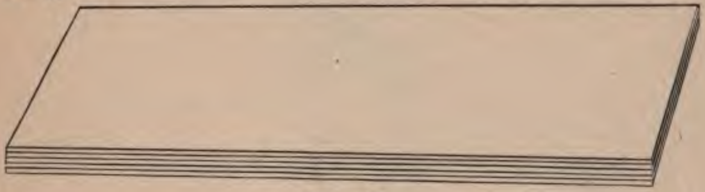


Fig. 23.

Take next the second board and treat it in the same way, and so on until all of the boards used in the previous lessons have their edges and ends filled with gauge lines.

LESSON VII.

TO MAKE A SQUARE BOARD.

In mechanics, as in arithmetic, strict accuracy of result is necessary. If the correct footing of a column of figures is 154 a pupil will find his work marked incorrect if he obtains 153 or 155. So in mechanics, if a pupil be required to make a board 2 in. wide, it cannot be marked correct if he makes it 1 and 63-64 in., or 2 and 1-64 in. Accuracy of result is of the utmost importance There are in mechanics, as in arithmetic

FOUR FUNDAMENTAL RULES

which need to be understood, as they are in constant use:—

RULE I—Measure accurately according to plan.

RULE II—Make perfect lines.

RULE III—Cut rapidly near the lines.

RULE IV—Cut carefully, exactly to lines.

In proportion as one understands these rules and practices them he will become skillful in tool-using.

To make Problem 7, Plate II, take a board $\frac{1}{8}$ in. thick, and

12 in. to 18 in. long, as may be convenient. Set gauge 2 ¼ in. and gauge from one edge on both sides of the board. This gauging can be done deeply, and the board will then split apart along the gauge line and the pupil has a piece 2 ¼ in. wide for use. If the end is sound wood, measure roughly 2 ¼ in. from the end and square around. If the end is not sound, or is filled with sand from lying in the lumber-yard, cut it off to clean sound lumber. Draw the knife a few times through the squared lines on both sides of the board and it will easily break, when you have a rough 2 ¼ in. square. This process is called "roughing out" and from the rough 2 ¼ in. square it is required to make a finished 2 in. square, as follows:—

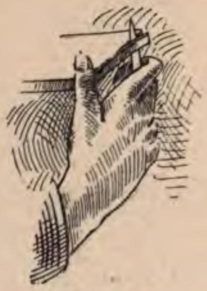


Fig. 24.

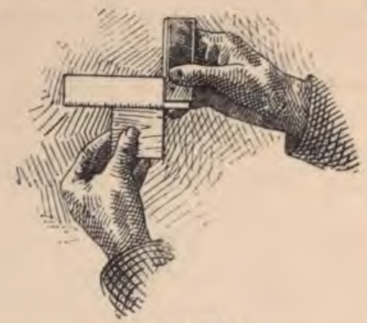


Fig. 25.

With finely-pointed pencil and straightedge draw a line on one side near one edge. Cut to this line holding the knife as in Fig. 24.

Test this cutting with the edge of the try-square blade to see if it is straight, and trim off such places as the test shows to be high. In testing hold the board in one hand and the square in the other, between the eye and a window. See Fig. 25.

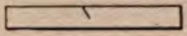


FIG. 26.

When no light can be seen between the board and the try-square blade the edge is perfectly true. Mark it with a pencil line that it may be known as the first edge trued. See Fig. 26.

In cutting wood the tool must not move against the grain. Thus in Fig. 27 a knife cutting from *c* to *a*, would be cutting *with* the grain. If cutting from *a* to *c*, the tool would cut very nearly parallel with the grain from *a* to *b*, but decidedly against the grain from *b* to *c*. Always examine the piece of wood and do not cut against the grain.

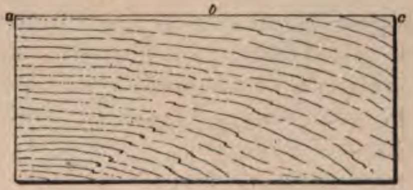


FIG. 27.

One more important fact may be mentioned here. A knife-blade will cut much more smoothly and easily if drawn downward or upward at the same time that it is driven forward. Figs. 28, 29, 30 illustrate this fact.

In Fig. 28, the successive positions of the blade show that the knife is driven forward without being drawn up or down. Fig. 29, shows that it is drawn downward at the same time that it is driven forward, and Fig. 30, shows that it is drawn upward at the same time that it is driven forward. The arrows indicate the direction forward.

In the operation shown at Fig. 29, the under surface of the board will be less likely to be torn by the knife-blade as it comes out, if the handle is inclined forward as there shown; and in the operation shown at Fig. 30, the upper surface of the board will be less likely to be torn by the knife-blade as it comes out, if the handle is inclined backward as there shown.

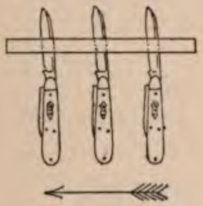


FIG. 28.

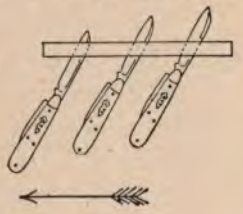


FIG. 29.

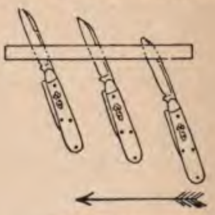


FIG. 30.

To finish the opposite edge, making it parallel with the first edge and 2 in. from it, set the gauge 2 in. *plus*.

The graduations upon the gauge stick which have answered for previous purposes are not sufficiently accurate for this. The rule must be used to measure the distance of the gauge-point from the gauge block, and the gauge point must not be set against the middle of the 2 in. graduation of the rule, but against the farther side of the graduation. This is what is meant by 2 in. *plus*, and in general all finishing or finish measurements must be made *plus*.

By *finish* measurements we mean those by which work is to be finished, in contrast with *rough* measurements, or those by which work is roughed out as stated above. The necessity for making finish measurements plus is caused by the fact that a small amount of wood is lost in the final smoothing away of tool marks, and work requires to be measured plus in order to allow for this.

Having set the gauge 2 in. plus, gauge a line *on* both sides of the board *from* the finished edge, and with sharp knife blade cut roughly near to the gauge line, Rule III; then cut exactly to the center of the gauge line, Rule IV. The new edge will now be high in its middle. See *a*, Fig. 31.

This high portion needs to be carefully cut off, leaving the edge straight across from corner to corner, as shown by dotted lines, Fig. 31. This operation is a closer application of Rule IV. The piece will now be just 2 in. wide. To make it 2 in. long first square around as near to one end as clean wood will allow, Rule II, using *knife* and try-square, and cut exactly to the lines, Rule IV. Next measure 2 in. *plus* from this finished end, Rule I, and square around again, Rule II. Draw the knife-point through these lines on both sides twice, or more if necessary, then cut as in Fig. 32. This last operation combines Rules III and IV.

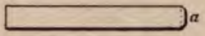


FIG. 31.

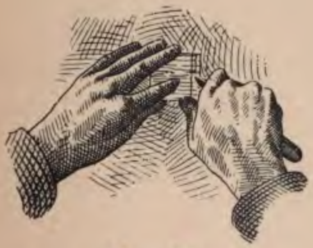


FIG. 32.

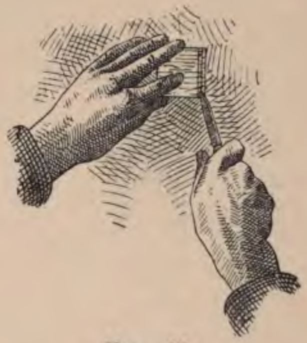


FIG. 33.

When the knife held as in Fig. 32, nearly reaches the thumb, change position and finish the cut, holding the knife as in Fig. 33. Fig. 34, is an edge-view of the board, illustrating its appearance after cutting on both of its sides in this manner.

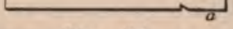


FIG. 34.

A few repetitions of this process removes the waste *a*, Fig. 34, when if the work appears similar to Fig. 31, it must be trimmed as that was to the dotted

We have now a piece just 2 in. square, and the successive steps taken in making it should be followed in the succeeding work, thus in setting the gauge or measuring the length, observe Rule I, measure accurately. In making gauge line or knife-line observe Rule II, make perfect lines. In removing the waste strips observe Rule III, work roughly near to lines; and in finishing to the center of gauge line, as also in finishing off the raised middle at Fig. 31, observe Rule IV, work exactly to lines. The finished square is shown in Problem 7, Plate II.

Pupils who have worked accurately will find their finished square boards agree with each other and with the teacher's, for the teacher should have an accurate model of his or her own make.

LESSON VIII.

THE CIRCLE.

Rough out from $\frac{1}{8}$ in. stock a piece 2 $\frac{1}{4}$ in. square, as in Lesson VII.

Find its center by laying the rule along its diagonals and marking with pencil short sections of these diagonals. See Fig. 35.

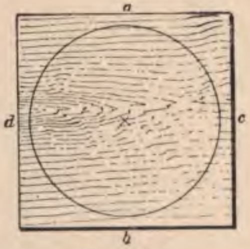


FIG. 35.

Set dividers 1 in. radius and describe a 2 in. circle as in Fig. 35. Suppose the grain to run in the direction indicated, then *a* and *b* will be the edges of the board, and *c* and *d* the ends.

In cutting to the circle the knife must start at *a* or *b*, that is, on the side of the grain, and move toward *c* or *d*, that is the end of the grain. The reason for this injunction will be discovered by those who neglect it, as the circle will be marred by splitting.

Rule I has been observed in setting the dividers and Rule II in describing the circle, now observe Rule III by cutting around the circle as above directed, keeping about 1-32 in. from the line. It would be well before doing this to draw with the pencil a diameter parallel with the grain, in order to save the time which would otherwise be consumed by the frequent necessary examination to discover the direction of the grain. The board will then appear as in Fig. 36.

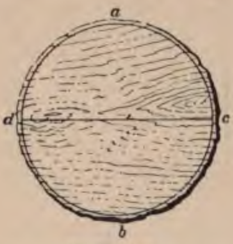


FIG. 36.

To complete the work observe Rule IV, cut carefully to line.

Compare finished work with that of other pupils and with teachers's model. The finished circle is shown in Problem 8, Plate II.

LESSON IX.

THE EQUILATERAL TRIANGLE.

Rough out from $\frac{1}{8}$ in. stock a board $2\frac{1}{4}$ in. square, as before, and straighten one edge of it. On this edge place two points just 2 in. apart; lay the work on the desk-cover, and against its straightened edge lay a straight-edged board $\frac{1}{8}$ in. thick. It will then appear as in Fig. 37, the points 2 in. distant from each other being shown at *a* and *b*. Set the dividers 2 in. and with points *a* and *b* for centers describe arcs cutting each other at *c*, join *a c* and *b c* with straight lines, using a finely-pointed pencil. Observe Rule III, cut roughly near to lines, and follow the directions about cutting with the grain, which in this problem will be to cut from *c* toward *a* and toward *b*, if the grain runs from *a* to *b* as directed. Should the pupil, however, begin the triangle by straightening an end instead of an edge, the cutting would need to be from *a* and from *b* toward *c*.

Proceed to finish the problem, observing Rule IV, cut exactly to line. Endeavor also to hold the knife blade with the side perpendicular to the side of the board, so as to cut the edge at right angles to the surface.

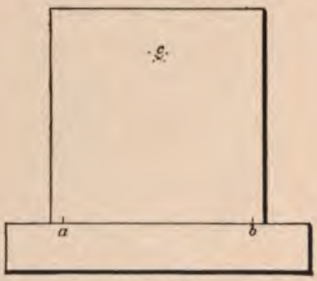


FIG. 37.

Remember this direction in all future work, especially when finishing, as required by Rule IV.

The completed equilateral triangle is shown in Problem 9, Plate II.

LESSON X.

THE OCTAGON.

Rough out from ⅛ in. stock a square 2 ¼ in., as before. Finish a 2 in. square as in Lesson VII. Find its center accurately by means of diagonals. See Fig. 38. Cut a right-angled notch in a waste piece of ⅛ in. board and hold it against a corner of the square board, as in Fig. 38.

Set the steel point of the dividers exactly in the corner at *a*, and spread the dividers until the pencil point rests on *c*; then swing the dividers to make the points *d* and *e*. Without changing the dividers set each of the three remaining corners of the square board into the notched block and mark other points corresponding to those just marked at *d* and *e*. The board will then appear as in Fig. 39, and with a fine pencil point and a straightedge the octagon may be completely laid out as in Fig. 40.

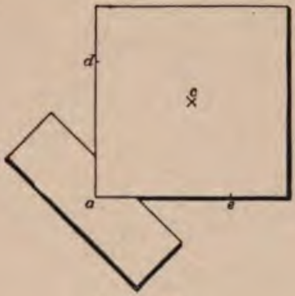


FIG. 38.

Now notice the direction of the grain, and cut roughly near to lines, Rule III; then cut carefully and exactly to lines, Rule IV. Take pains also to hold the knife with its side perpendicular to the side of the board, as described under Lesson IX, and observe the directions concerning drawing the knife, illustrated in Figs. 29 and 30. The completed octagon is shown in Problem 10, Plate II.

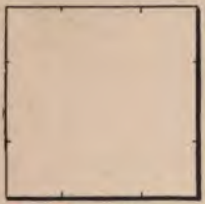


FIG. 39.

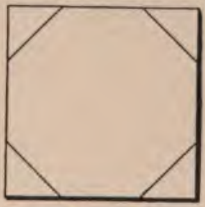


FIG. 40.

LESSON XI.

THE HEXAGON.

Rough out from $\frac{1}{8}$ in. stock a board 2 $\frac{1}{2}$ in. x 2 $\frac{1}{4}$ in. Find the center roughly by means of diagonals, set the dividers 1 in.

by means of the rule, and from the center of the board describe a 2 in. circle. The board will then appear as in Fig. 41.

With straightedge and pencil draw a line parallel to the side *a b*, just touching the circle. The board will then appear as in Fig. 42.

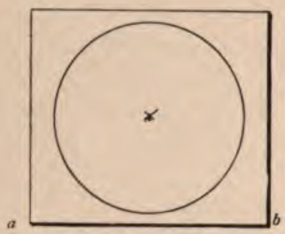


FIG. 41.

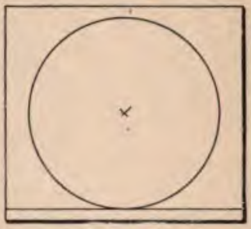


FIG. 42.

Cut carefully to this last-made line, observing all previous instructions.

Set the gauge 2 in. plus, gauge a line just touching the upper side of the circle and cut carefully to that line. Lay the board on the desk-cover, against the beam of the try-square or some straightedge of thicker material than the board itself; also lay upon the board and against the thick straightedge an equilateral triangle made in Lesson IX in such a position that

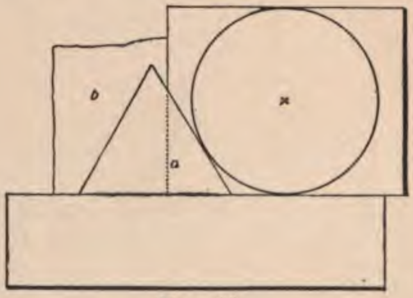


FIG. 43.

one side of the triangle shall be tangent to the circle on the board. See *a*, Fig. 43. As some portion of the triangle projects beyond the board and is therefore unsupported, put a waste piece underneath to support it. See *b* Fig. 43. Draw a fine pencil line on the board against the side of the triangle which is tangent to the circle, then adjust the board and triangle to draw the remaining three lines necessary to complete the hexagon. The board now has the appearance shown in Fig. 44.

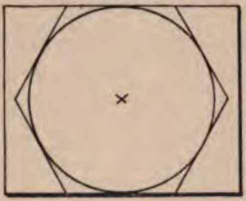


FIG. 44.

Finish cutting the hexagon, observing Rules III and IV, and other detailed instructions which have been given.

The completed hexagon is shown in Problem 11, Plate II.

We have circumscribed this hexagon about a 2 in. circle. A hexagon can also be inscribed in a circle as follows :—

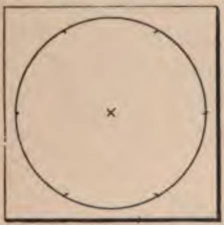


FIG. 45.

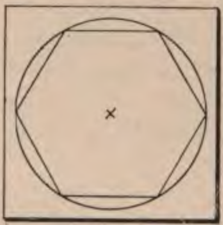


FIG. 46.

Rough out a piece of wood 2 ¼ in. square, center it and describe a 2 in. circle as before. Without changing the dividers notice that they will space around the circle just six times. See Fig. 45. Join the adjacent points with straight lines, and we have an inscribed hexagon. See Fig. 46. Of course the inscribed hexagon is smaller than the circumscribed hexagon, the 2 in. circle touching the corners of the inscribed and the middle portion of each side of the circumscribed hexagon.

LESSON XII.

THE PENTAGON.

Rough out from $\frac{1}{8}$ in. stock a board 2 $\frac{1}{4}$ in. square, center it and describe a 2 in. circle; set the dividers so that they will make five spaces around the circle. The exact amount of this setting will have to be found by repeated trials, though it is very nearly 1 and 3-16 in. Place these points and the board will appear as in Fig. 47. Join the adjacent points with straight lines and cut to the lines, observing directions previously given. The completed pentagon is shown in Problem 12, Plate II. This pentagon is inscribed in a 2 in. circle. To circumscribe a pentagon about a 2 in. circle, draw lines touching the circle parallel to each of the sides of the inscribed pentagon, or draw a circle 2 and 15-32 in. diameter and inscribe a pentagon within it; such a pentagon will be of the desired size.

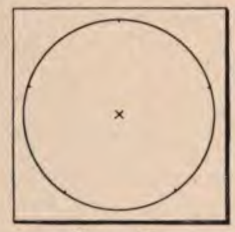


FIG. 47.

LESSON XIII.

THE ELLIPSE, THREE BY TWO INCHES.

Rough out from $\frac{1}{8}$ in. stock a board 3 $\frac{1}{4}$ in. x 2 $\frac{1}{4}$ in. Straighten one edge and mark it. This edge may be straightened as in Lesson VII, by drawing a fine pencil line on the face* near one edge of the board and cutting to it. Draw a fine pencil line parallel to the straightened edge and along the middle of the board. Square a line across the middle of the board as in Fig. 48.

---

*The term face is often used to denote the *principal* face of a board, The rule may be used for a straightedge in drawing pencil lines, not however in making knife lines. From the intersection *c* lay off to the right and left 1 ½ in. and we have the long diameter, *a d*, of the ellipse. See Fig. 49. From *c* lay off above and below, 1 in. each way, and we have the short diameter, *b e* of the ellipse. Set dividers to the distance *a c*, that is half of the long diameter, and with their steel foot placed at *e* describe arcs cutting the long diameter and the work will appear as in Fig. 49. The points where these arcs cross the long diameter are the foci of the ellipse, each point by itself being a focus.

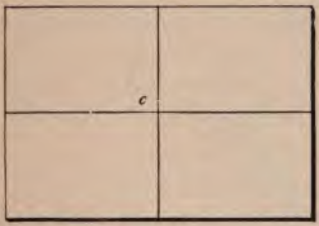


FIG. 48.

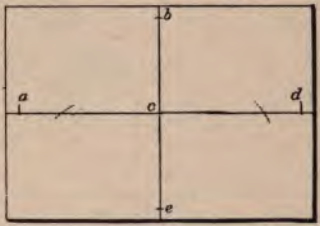


FIG. 49.

Take three common pins, and insert them at *b* and at the two foci, inclining their points toward the center at such an angle as to carry their heads about ⅛ in. away from perpendicular. A plan view of the boards and pins is seen in Fig. 50 and a front elevation of them in Fig. 51.

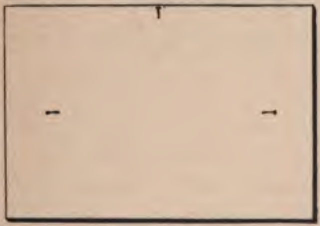


FIG. 50.

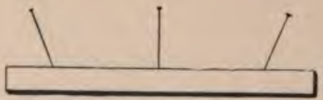


FIG. 51.

Take a piece of linen thread 10 in. long and tie it in a hard knot around the pins, close to the board. If the first knot is tied behind a foci-pin as in Fig. 52, it will hold without slipping while the second knot is being tied. Fig. 53 illustrates the form known as a hard knot, that is, one which will not easily loosen. The knot represented in Fig. 54 will easily loosen.

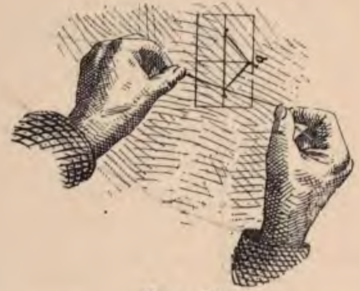
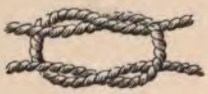


FIG. 52.

After tying, cut off the waste ends leaving them about ¼ in. long, draw out the pin at *b* putting a finely-pointed pencil against the thread in its place. The thread is now looped around the pencil point and the two foci-pins. Hold the pencil point on the wood and against the thread, giving a little more pressure toward the wood than toward the thread, and inclining the pencil top toward the center of the board sufficiently to have the outer side of the cone caused in sharpening the pencil to be perpendicular to the surface of the wood. With the pencil so held move it around on the board and an ellipse will be described passing through the ends of the diameters *a*, *b*, *d*, *e*, Fig. 49. Remove the pins and cut to lines, observing Rules III and IV, and such other directions already given as apply.



Hard Knot.
FIG. 53.

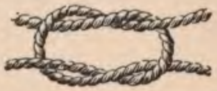


FIG. 54.

The completed ellipse is shown in Problem 13, Plate II. If preferred this ellipse may be drawn free-hand.

LESSON XIV.

THE OVAL, THREE BY TWO INCHES.

Rough out from ⅛ in. stock a board 3 ¼ in. x 2 ¼ in. Straighten one edge and draw a fine pencil line parallel to it along the middle of the board. Upon this line lay off 3 in. See *a b*, Fig. 55.

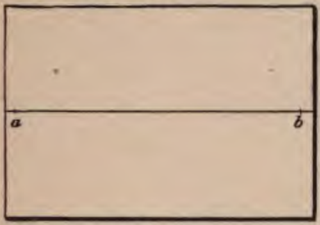


Fig. 55.

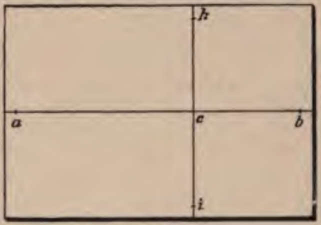


Fig. 56.

Take a piece of thick white paper or thin cardboard, cut it about the same size as the board and be sure that one edge is straight. Draw a pencil line parallel with this edge, along the middle, and lay off 3 in. It now appears like the board shown in Fig. 55. From *b* measure 1 ⅛ in., and find *c*, Fig. 56. Through *c* draw a pencil line square with the straightened edge, and from *c* measure 1 in. both ways, finding the points *h* and *i*. Then the points *a* and *b* will be the long diameter of the oval, while *h* and *i* will be the short diameter. Draw a free-hand curve from *h* through *b* to *i*, which will be nearly but not quite a semicircle. From *h* through *a* to *i*, draw a curve, which will be nearly a semiellipse. See Fig. 57.

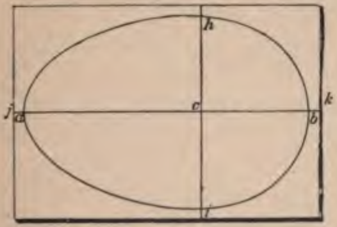


Fig. 57.

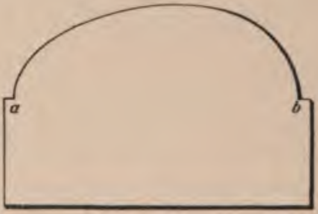


Fig. 58.

Lay this paper on a clean board, and with a sharp knife point cut from *j* through *a*, *h*, *b*, to *k*, when the outline of the paper will present the appearance of Fig. 58. This piece of paper or cardboard so prepared we call a templet. Place this templet on the board, the corner *a* of the templet corresponding with the point *a* on the board, Fig. 55 and the corner *b* of the templet corresponding with the point *b* on the board, then with a finely-pointed pencil mark a line on the board against the edge of the templet, from *a* around to *b*. Turn the templet over, make the points *a a* and *b b* again to correspond, and mark on the board as before.

The complete oval is now laid out on the board, the two sides being made uniform by using the templet; and it only remains to work to the lines, as in previous problems. The completed oval is shown in Problem 14, Plate II.

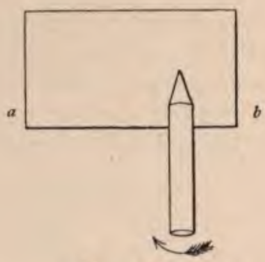


FIG. 59.

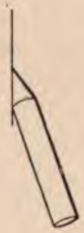


FIG. 60.

A word about sharpening pencil points. A pencil cone should not be cut more than $\frac{5}{8}$ in. from the point for woodwork. To put a fine point on it after cutting, tack a piece of 00 sandpaper on each desk-cover at the upper left-hand corner. One sheet of 00 sandpaper torn in four pieces each way, making sixteen pieces in all, will furnish pieces large enough for the purpose. Six sheets will make ninety-six pieces, allowing four to be tacked in a pile on each desk-cover for a class of twenty-four pupils, and when the top piece has been used so as to be of no further service it can be torn off, leaving a fresh surface exposed. Fig. 59 illustrates the manner of sharpening the pencil. Let the cone of sharpening rest on the paper, draw the pencil from *b* toward *a*, at the same time rolling it in the direction of the arrow. Fig. 60 is a left elevation of Fig. 59.

It will be seen that the pencil is ground as it is drawn, and that the grinding is carried around the cone by turning the pencil as indicated by the arrow. A little care will make a fine point quickly and with no waste of pencil. Marks made with a fine pencil point should always be lightly drawn, that the point may be perserved as long as possible. In no case should a pencil be wet.

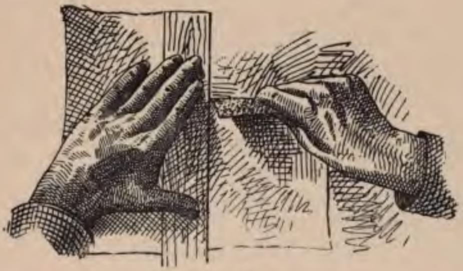


FIG. 61.

Sandpaper can easily be torn by holding a sharp edge of some material firmly to its paper side. See Fig. 61.

The upper edge of the saw-blade is excellent for this purpose, although the sharp corner of a board will answer.

LESSON XV.

THE VASE.

Rough out from $\frac{1}{8}$ in. stock a board 3 $\frac{1}{4}$ in. x 2 $\frac{1}{4}$ in.; straighten one edge, and draw a fine pencil line parallel with it along the middle of the board. Cut the ends of the board off square as in Lesson VII, leaving the board 3 in. long. From the point *a*, Fig. 62, measure along the end of board 11-16 in., each way, and place the points *b* and *c*. From the point *d*, do likewise and place *e* and *f*. Draw short lines from *e* and from *f*, parallel to the middle line, measure off 1-16 in. on each of them, and place the points *g* and *h*. Lay a straight-edged piece of board against the left end of the work, as in Fig. 62, set dividers 1 in., place the metal point of dividers on *c*, and describe an arc cutting the line *a d*, at *o*. With *o* as a center and 1 in. radius describe the arc of a circle, as shown.

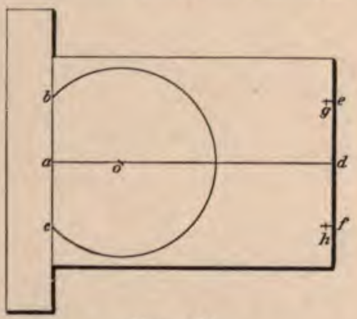


FIG. 62.

Fig. 63 represents work completed thus far. Now find a center from which an arc having a 1 in. radius can be described passing through the point *h* and tangent to the arc already drawn. Place a waste board against the lower edge of the work, as at *m n*, Fig. 64, and find the point *p* by trial; from this point describe the required arc. Repeat the process on the upper side of board, and describe the arc from *g*.

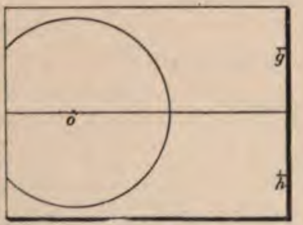


FIG. 63.

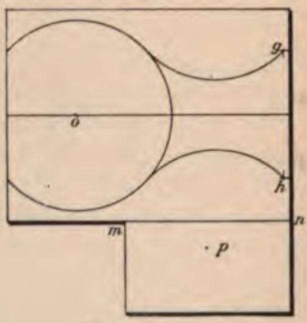


FIG. 64.

The point *p* can be found by a mechanical method, although some teachers will hesitate about trying it with fifth-year pupils. The method is as follows :—

With *h* as a center and dividers set 1 in. describe an arc on the waste piece. See Fig. 65. From the center *o*, draw the straight line *o p*, touching this arc; with the intersection *l* as a center and dividers set 1 in. draw the arc *r s*. The intersection *p* is the center required, as it is 1 in. from *h* and from *l*.

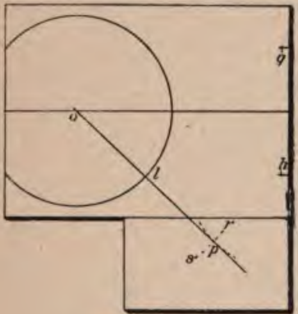


FIG. 65.

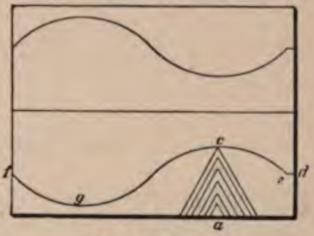


FIG. 66.

Fig. 66 shows the drawing of the vase complete. In preparing to cut it, first cut a small V in the edge of the board at *a*. By successive cuts enlarge this V until it nearly reaches the line at *c*; then observing Rules III and IV and other instructions already given, cut from *d* to *c*; cut from *g*, both ways to *c* and to *f*. Treat the opposite side in the same manner. The completed vase is shown in Problem 15, Plate II.

LESSON XVI.

THE CLOVER LEAF.

Rough out from ⅛ in. stock a board 3 ¼ in. x 2 ¼ in. Straighten one edge and draw parallel to it the middle line *a b*, as in Fig. 67. From *b* lay off ⅝ in. and place the point *c*. With *c* as a center and dividers set ½ in. describe a circle; with centers found by trial describe two more circles of the same size, touching the first circle and touching each other on the straight line. If preferred these last two centers can be found mechanically, thus :—

With *c* as a center and a radius of 1 in. describe arcs at *o*, *o*; draw lines parallel to *a b* and ½ in. from it; the intersections *o*, *o* are the centers required. Parallel to the middle line and ⅛ in. on each side of it draw the lines *i k*, joining the circles with the left end of the board. From *l* the right-hand side of the circle first drawn, measure 3 in. and draw a short line *d e*. Observe Rules III and IV and other necessary instructions and cut to the lines.

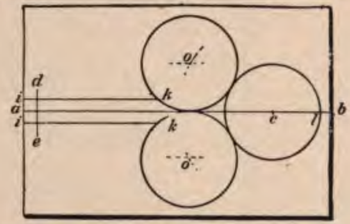


FIG. 67.

The chief difficulty in cutting the clover leaf will be found in finishing to the acute angles where the circles join, and the suggestions made in connection with Figs. 29 and 30 will be helpful.

The finished clover leaf is shown in Problem 16, Plate II.

LESSON XVII.

THE CRESCENT.

Rough out from ⅛ in. stock a piece 2 ¼ in. square and straighten one edge. Draw a middle line *d e*, parallel to the straightedge, and a middle line, *a o*, at right angles to it. See Fig. 68. With the intersection *c* as a center and a radius of 1 in. describe a semicircle; place a point *b* ½ in. from *a*. Now find a center and radius with which a circle can be made to pass through the points *d*, *b* and *e*. This may be done by trial, or if a mechanical method is preferred, observe the following :—

With *b* as a center, and then with *d* as a center, describe arcs cutting each other at *g* and *h*; draw the line *g h*, and produce it to *o*. The intersection *o* is the center required, since every point on the line *a o*, is equi-distant from the points *d e*; and every point on the line *g o* is equi-distant from the points *d* and *b*.

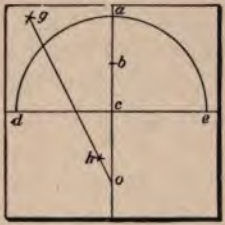


FIG. 68.

The completed drawing is shown in Fig. 69, the grain running in the direction *d e*. To cut the problem, first remove the upper portion, cutting from *a* toward *d* and toward *e*; it will then appear as in Fig. 70. Next, remove the lower half, and it will appear as in Fig. 71. Next, by successive V cuttings, as in Fig. 66, bring the problem to appear as in Fig. 72, and then cut from *d* toward *b* and from *e* toward *b*.

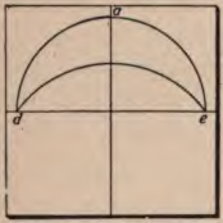


FIG. 69.

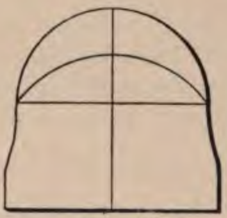


FIG. 70.

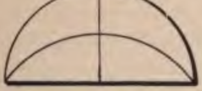


FIG. 71.

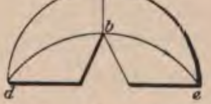


FIG. 72.

In beginning these cuts from *d* and from *e* great care must be taken, and the directions given in Figs. 29 and 30, must be observed. The completed crescent is shown in Problem 17, Plate II.

LESSON XVIII.

THE STAR.

Rough out from $\frac{1}{8}$ in. stock a board 2 $\frac{1}{4}$ in. square, center it by diagonals and describe a 2 in. circle. As in making the pentagon, divide the circumference into five equal parts; join each point by straight lines drawn each way to the second point from it, as in Fig. 73. Draw the line *a b*, parallel with the grain, for future convenience. Cut first to the circle, and the work will appear as in Fig. 74.

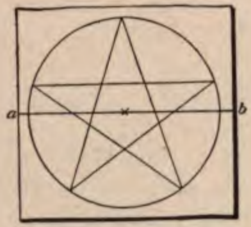


FIG. 73.

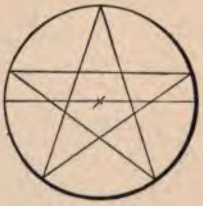


FIG. 74.

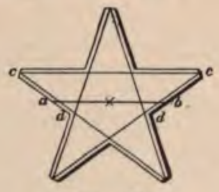


FIG. 75.

As in Fig. 66, cut a V in each of the five spaces to be wasted, observing Rule III. This will necessitate cutting against the grain on the lines *c*, *d* and *e d*, which can be done by observing Figs. 29 and 30. The work will then appear as in Fig. 75.

Observe Rule IV and finish the work, cutting toward the point *c* and *e* in finishing them, and toward the center in finishing the other three points. The star will be found more difficult than any problem hitherto made, and the pupil will be skillful who succeeds with it. If preferred the points can be cut as in Figs. 32 and 33. The finished star is shown in Problem 18, Plate II.

LESSON XIX.

THE ARROW.

Rough out from $\frac{1}{8}$ in. stock a board 6 $\frac{1}{4}$ in. x 2 $\frac{1}{4}$ in. Straighten one edge; gauge 1 in. on both sides and draw the knife through the gauge lines and the board will easily separate; cut off the high portion in the middle of the edge, as described in Fig. 31. We have now a piece 6 $\frac{1}{4}$ in. rough length x 1 in. finished width. With finely-pointed pencil, square two lines *d e* and *p q*, across it, 6 in. apart. See Fig. 76. Also draw a pencil line *u s*, along the middle.

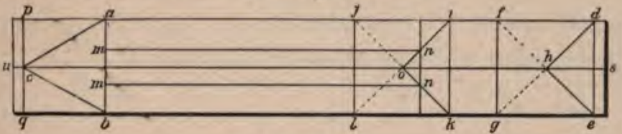


FIG. 76.

Set the dividers 1 in. and with the intersection *c* as a center describe an arc at *a*; from *a* square the line *a b*; join *a c* and *b c*, with straight fine pencil lines; these lines form an equilateral triangle and constitute the head of the arrow. To lay out the feather on the opposite end measure from *d* 1 in., and place the point *f*; square with pencil the line *f g*, and draw the half diagonals *d h* and *e h*.

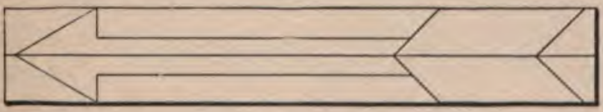


FIG. 77.

Place the point *i*, 1 $\frac{1}{2}$ in. from *d* and the point *j* 1 in. from *i*; square the lines *i k*, and *j l*, and draw the semidiagonals *i o* and *k o*. Set the gauge 5-16 in. and gauge the lines *m n*. Square around the board at *m* and at *n*, with very fine pencil lines, and gauge two corresponding lines on back of board and the work will appear as in Fig. 77.

Observe Rules III and IV, with other important directions given in previous lessons, and cut to the lines. The head should be cut from *a* and from *b*, Fig. 76, toward *c*; the rear end of feather can be cut from *d* and from *e* toward *h*, although against the grain, if care is used and if Figs. 29 and 30 are recalled. The work will appear as in Fig. 78.

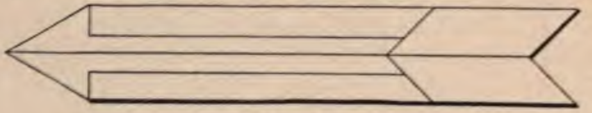


FIG. 78.

To remove the middle portions, first cut a V as at *r*, Fig. 79, and make successive cuts each side of it as shown, until all of the waste stock is removed, observing Rule III. Then finish the work on that side, observing Rule IV. Great care will be necessary not to split off the corner at *t*; the successive cuts made as that point is approached must be fine, and the information given in Figs. 29 and 30 must be utilized. The upper side of the arrow is to be finished in the same manner. The completed arrow is shown in Problem 19, Plate III.

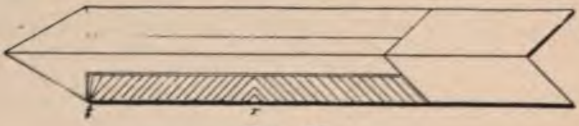


FIG. 79.

A great diversity will be discovered in the capabilities of different pupils, some being able to make a given problem twice or even thrice while others are making it once. Let such pupils repeat the problem for the hour as many times as they succeed in doing it well. They will gain facility thereby. The class should usually advance when nearly all of the members have performed one problem, as the inability of a few to succeed should not retard the advancement of the majority. It is well, however, to let the entire class make duplicates of some of the more interesting problems to carry home, as they are gratified and parents are interested and informed. Problems 5, 7, 8, 13, 14, 19, 20, on Plates I, II and III, are suggested for these duplicates.

LESSON XX.

THE RULE.

Take the remaining half of the rough piece from which the arrow was made and finish it to $\frac{7}{8}$ in. width and 6 in. length. If this remainder has been used to make a second arrow, rough out a new piece and finish it 6 in. x $\frac{7}{8}$ in.

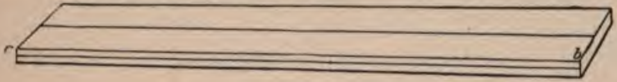


Fig. 80.

Set the gauge 1-16 in. and gauge a line along the middle of one edge; also *pencil* a line along the middle of one side. A perspective view of the board so prepared is seen in Fig. 80.

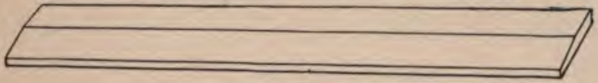


Fig. 81.

Observing Rules III and IV, cut away the corner *a b* to the above-mentioned middle lines, and the work will appear as in Fig. 81.

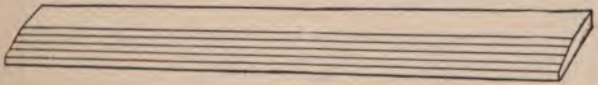


Fig. 82.

Along the beveled face so made draw three lines. One line should lie along the middle of the face and the other two along the middle of each half. See Fig. 82.

To graduate the rule, lay it on the desk-cover with the beveled edge away from you, and lay the standard rule against the beveled edge. See Fig. 83.

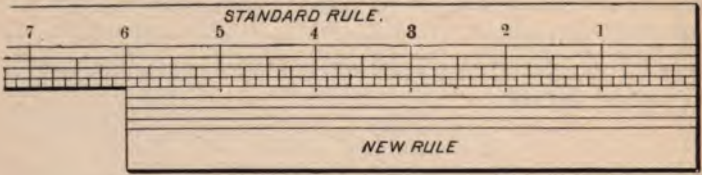


FIG. 83.

With the pencil place points on the new rule against every inch graduation of the standard rule as in Fig. 83; remove the standard rule, block up the new rule by putting ½ in. thickness of wood under it, and, by means of try-square and sharp pencil point, square lines back across the entire width of the beveled face. The work will then appear as in Fig. 84.

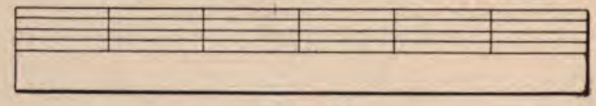


FIG. 84.

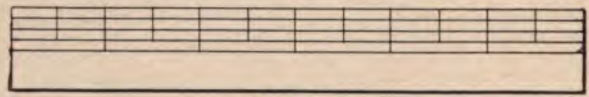


FIG. 85.

Lay the two rules again as in Fig. 83 and place points on the new rule against every eighth-inch of the standard rule; remove the standard rule, block up the new rule as before, and square from the *half-inch* points back to the third line on the beveled face, and the work will appear as in Fig. 85.

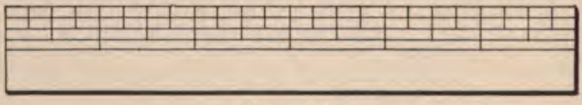


FIG. 86.

Square from each *quarter-inch* point, back to the second line on the beveled face, and the work will appear as in Fig. 86. Square from the remaining eighth-inch points back to the first gauge line, and with a finely-pointed pencil make figures against each inch graduation. The completed rule is seen in Problem 20, Plate III.

LESSON XXI.

LETTERS.

A great deal of interest can be aroused in making the letters of the alphabet, and constructing words and mottoes from them. If the cut letters are tacked to a background of blue cardboard they will show to good advantage.

On Plate IV will be found a complete alphabet of simple block letters, each of which is 3 ½ in. high and most of them 2 in. wide. A detailed description of the method of making the letters H, O, B and S, will give the principal instruction necessary.

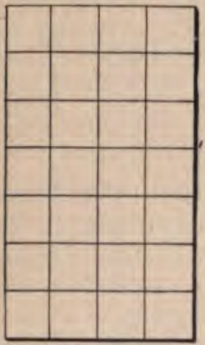


FIG. 87.

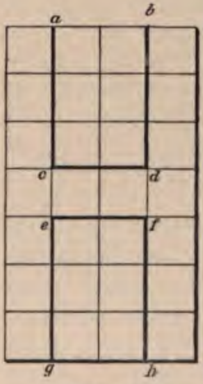


FIG. 88.

A piece of wood nearly 6 in. square should be provided by each pupil for a cutting-block, and his letter be kept on it, so as not to cut the desk-cover when the knife point passes through the work.

To make H, rough out from ⅛ in. stock a board 3 ¾ in. x 2 ¼ in. and finish it 3 $\frac{1}{2}$ x 2 in. Draw fine pencil lines on the board $\frac{1}{2}$ in. apart, both horizontally and vertically.

These lines will lay out the board in $\frac{1}{2}$ in. squares, 4 squares horizontally and 7 squares vertically, as in Fig. 87. Redraw heavier the lines *a c*, *b d*, *c d*, *e f*, *e g*, *f h*, as in Fig. 88, and cut to these heavy lines in the manner described in Figs. 32 and 33.

Care will be needed not to break the central bar of the H, as the grain runs vertically through it.

Erase all construction lines. The completed H is shown in Problem 21, Plate III.

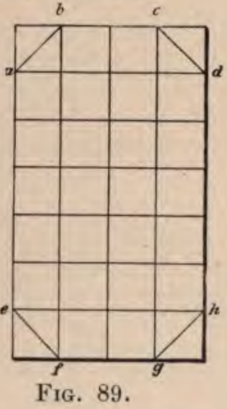


FIG. 89.

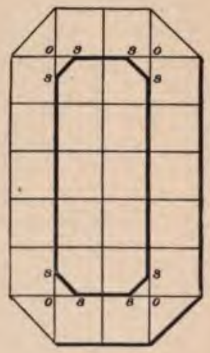


FIG. 90.

The lines on Fig. 87 are called construction lines, and are used as a basis in laying out letters, although no letter alone utilizes all of them. They should be lightly drawn, in order to be easily erased. In laying out a given letter any line or lines which a pupil clearly sees to be unnecessary to its construction may be omitted.

To make the letter O, rough out from $\frac{1}{8}$ in. stock a board as before, 3 $\frac{3}{4}$ in. x 2 $\frac{1}{4}$ in. and finish it 3 $\frac{1}{2}$ in. x 2 in., or if many letters are to be made it will be well to prepare a strip 12 in. rough length x 2 in. finish width, and from this cut off 3 $\frac{1}{2}$ in. pieces successively, cutting as in Figs. 32 and 33.

Having prepared the piece 3 $\frac{1}{2}$ x 2 in. for the letter O, lay it off in ½ in. squares, as in Fig. 87; draw diagonals *a b*, *c d*, *e f*, *g h*, in the corner squares, as in Fig. 89, and cut to them.

From the intersections *o*, Fig. 90, measure 3-16 in. each way, place the points *s s*, and draw the oblique lines *s s*. Redraw heavier the lines shown, and cutting to them as in Fig. 32, remove the central portion of the board.

Erase all construction lines. The completed O is shown in Problem 21, Plate III.

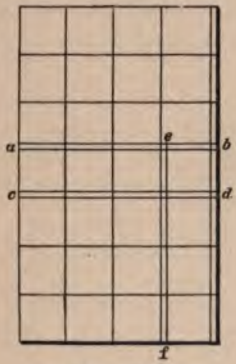


FIG. 91.

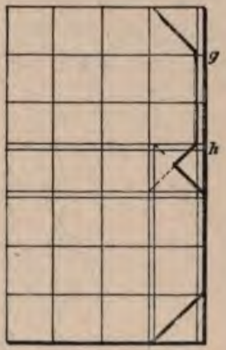


FIG. 92.

As some of the letters are wider than 2 in. it will be necessary to prepare wider strips for them as follows:—

Two strips 12 in. rough length x 2 ¼ in. finished width for A, K, R, T, V and Y. One strip 12 in. rough length x 2 ½ in. finish width Q, X and Z, and one piece 2 and 1-16 in. wide for B and S. M and W take still wider pieces, as will be explained later.

In getting these strips to a width the class will need straight-edges of sufficient length. Rules will answer if carefully straightened by a skilled workman, although pieces of ⅛ in. basswood 16 in. x 2 in. with carefully straightened edges are preferable.

To make B, finish a piece 3 ½ in., x 2 and 1-16 in. and line it as in Fig. 91, in ½ in. squares, leaving the extra 1-16 in. at the right. The lines *a b* and *c d* are raised 1-16 in., and the line *e f* is carried 1-16 in. to the right, as shown.

Draw diagonals as in Fig 92, and cut to them; also cut to the heavy line *g h*. Measure 3-16 in. from the dotted intersections *o*, Fig. 93, and draw the short oblique lines *s s*; cut internally to these oblique lines and to the heavy lines joining them. Erase all construction lines.

The finished B is seen in Problem 21, Plate III.

To make S from ⅛ in. stock finish a piece 3 ½ in. x 2 and 1-16 in., and line it as in Fig. 91. Draw diagonals and the short oblique lines shown in Fig. 94, following directions given for making similar lines in constructing B.

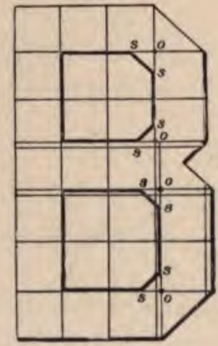


FIG. 93.

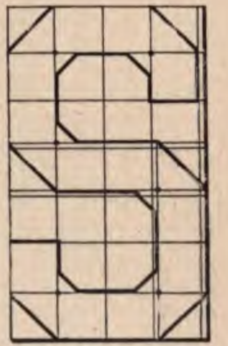


FIG. 94.

Redraw heavier such necessary portions of vertical and horizontal lines as are shown in Fig. 94, and cut to these heavily-drawn lines. The completed S is shown in Problem 21, Plate III.

In making the letters C, D, G, J and U study the diagrams of these letters on Plate IV and follow the directions given for H and O. The letters P and R are made with slight changes from B, though R requires a board 2 ¼ in. wide. In making the letter A it is hardly necessary to lay out the board in ½ in. squares, but simply to measure on the lower end ½ in. from each corner and place two points ½ in. apart, midway of the upper end, when the two main bars of the letter may be easily drawn. Next draw the middle bar ¾ in. from the lower end of the letter.

These directions for A are sufficient for V and Y, except that the tops of the Y need to measure 9-16 in. horizontally, in order to be ½ in. wide. M requires a board 3 in. wide and W 3 ½ in. wide. X is 2 ¼ in. at the top and 2 ½ in. at the bottom. The oblique bars of K, Q, R, X and Z need to measure 9-16 in. horizontally, for the same reason as those of Y.

The letters E, F, I, L, N and T do not need any especial directions, aside from the suggestions already given and those which can be gained by a study of Plate IV. On the lower portion of Plate IV are seen more tasteful shapes of the curved letters, which are made by using arcs of circles in place of oblique lines. Ornamental shapes can be devised if desired.

LESSON XXII.

THE MONOGRAM.

The monogram shown on Plate III is M. T. S., (Manual Training School). Rough out from ⅛ in. stock a board 5 ½ in. long x 4 ⅞ in. wide and finish it 5 ¼ in. x 4 ⅝ in. Draw fine pencil lines lengthwise ⅝ in. and ⅜ in. apart alternately, as in Fig. 95. Square upon it lines ⅝ in. apart, beginning at the top;

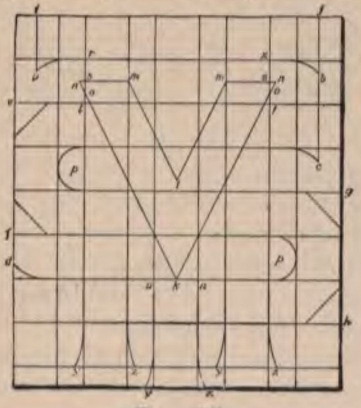


FIG. 95.

the last squared line will come ¼ in. from the bottom. Draw the line $j\ c$, along the middle of the right ⅝ in. vertical section, crossing three horizontal sections and passing 3-16 in. into the fourth; draw the line $i\ a$, along the middle of the ⅝ in. vertical section, crossing one horizontal section and passing 3-16 in. into the second; draw the arcs $a\ r$, and $b\ x$, tangent to the horizontal line at the points r and x; in like manner draw corresponding arcs at c and d. The arcs y and z at the foot of the T and of the M diverge ⅛ in. From the corners e, f, g and h measure ½ in. each way and draw oblique lines.

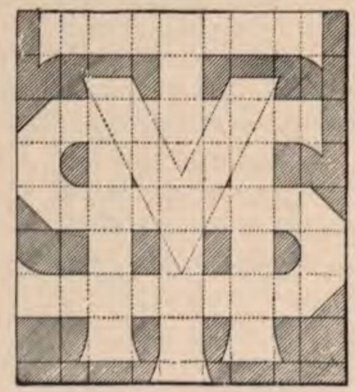


FIG. 96.

From the points $m\ m$, draw the lines $m\ n$, midway of the second horizontal section from the top; find the point k in the middle of the third horizontal line from the bottom; find the points o, o, midway between the intersections s and t, and draw the lines $k\ o$, $k\ o$, extending them to $n\ n$; draw $m\ l$, $m\ l$, parallel to $n\ k$, $n\ k$; draw semicircles at p and p.

Cut away the portions section-lined in Fig. 96. Redraw heavier such construction lines as are shown in Problem 22, Plate III, and erase all other construction lines.

In addition to the above, other elementary problems may be made, as isosceles triangle or half-square, 30° and 60° triangle, rectangle and rhomb, and a great variety of ornamental work may be devised by a repetition and combination of elementary problems. Figs. 97, 98, 99, 100 and 101 illustrate four groupings of the star, crescent, circle and square. Outlines of objects may be drawn and cut, as the outline of a hand, a leaf, a lamp, a pitcher, a map or an open book. For illustration see the outline of a hand, Plate II. Original representations should also be encouraged. Geometrical puzzles, such as the Chinese and Pythagoras, will interest pupils and are useful, as they require accurate workmanship.

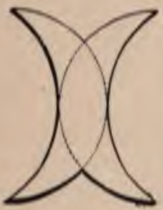


FIG. 97.

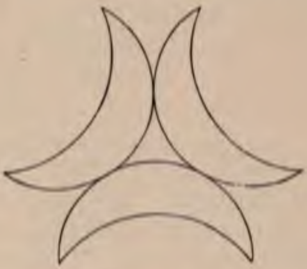


FIG. 98.

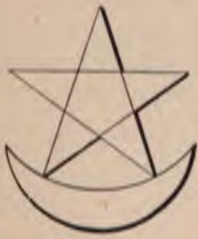


FIG. 99.

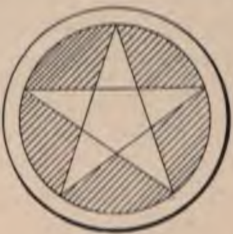


FIG. 100.

A set of Dominoes involves more simple problems.

At many points through the course, divisions or groups of problems may be given as follows :—

Four right isosceles triangles to form a square, two semicircles or four quadrants to form a circle, a semiellipse and a semicircle to form an approximate oval, six equilateral triangles to form a hexagon, three hexagons grouped to show how surface can be entirely covered by hexagons, a pentagon and five triangles, or a hexagon and six triangles to form a star.

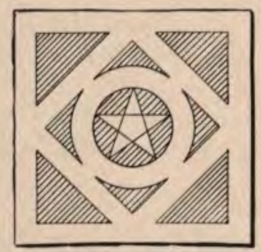


Fig. 101.

LESSON XXIII.

THE BOX.

The first year of the course may be fittingly closed by making a box of sufficient dimensions to hold the work of the year. Take stock $\frac{1}{8}$ in. thick and make two boards 9 in. long x 2 in. wide for sides of the box; and from stock $\frac{1}{4}$ in. thick make two boards 4 $\frac{3}{4}$ in. long x 2 in. wide for ends. Nail them as in Fig. 102, with $\frac{1}{2}$ in. No. 21 steel-wire brads. They will constitute a frame 9 in. long x 5 in. wide, outside. Fig. 103 is a view of the side of the box showing location of brads in each end, with one nail about 3-16 in. from each edge of the board, and two others so placed as to divide the space equally.

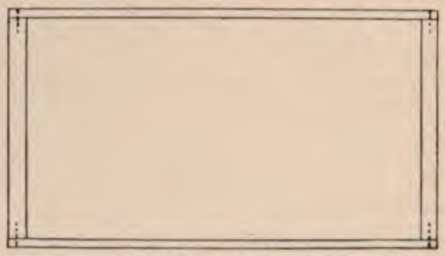


Fig. 102.

The edges of the frame may be nicely trued before nailing on the bottom board, by using a piece of No. 1 sandpaper, folded around a board. One-eighth of a sheet of sandpaper is large enough for this purpose, and any of the problems from 1 to 4, Plate I, may be used for the board. The sandpaper is to be folded around near one end of the problem board, and while half of the edge surface as shown in Fig. 102 is being sanded, the opposite end of the problem board must rest on the other half of the edge surface, to insure trueness, and vice versa.

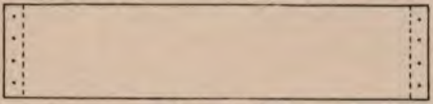


FIG. 103.

Take ⅛ in. stock and make two boards 9 and 1-64 in. long x 5 and 1-64 in. wide. One of these is for a bottom board and one for a cover. All of this material must be made in accordance with rules previously given.

To fasten the bottom board to the ends of the frame use ½ in., No. 21, steel-wire brads; to fasten the bottom board to the sides of the frame use ⅜ in., No. 22, steel-wire brads. Fig. 104 is a view of the bottom of the box, showing location of brads.

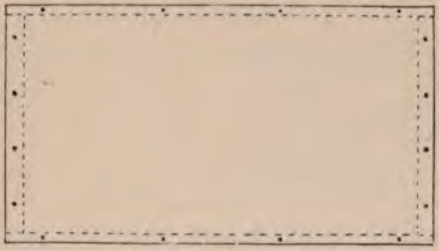


FIG. 104.

Put one brad about ⅝ in. from each corner on ends and sides; put two others along each edge and end, so as to divide the space equally, taking care to start them at proper distance from the edge and the end, so as to have them enter the stock of the frame midway of its thickness.

Make two cleats of ⅛ in. stock, 4 ¾ x 1 in. to keep the cover in position. Fig. 105 is a view of the cover with these cleats, showing the brads; one ⅜ in., No. 22 steel-wire brad is to be placed 3-16 in. from one end and one side of the cleat; another brad is to be placed 3-16 in. from the opposite side and opposite end; the remaining two are to be placed at equal distances as shown.

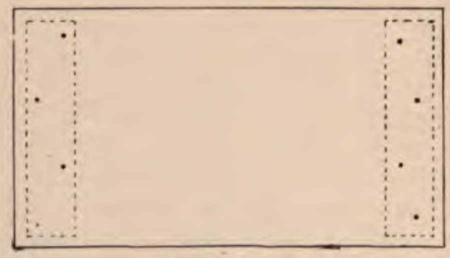


Fig. 105.

Lay the cover on the desk, bottom side up; lay a cleat on the cover with its ends equi-distant from the edges of the cover and its edge ¼ in. from the end of the cover, and drive the two end brads; turn the cover over and drive the other two brads; draw out the brads first driven and put them in from the top side of the cover; lay the cover with cleats down on a piece of iron and clinch the brads. With the cover on the box true off all surplus length and width of the bottom board and cover by means of sandpaper folded over a block. The completed box is shown in Problem 23, Plate III.

Probably not all the problems for this or the succeeding years can be performed in forty lessons of three-quarters of an hour each, but they will furnish a reserve for pupils who work rapidly or are ambitious to spend some time on them at home.

SECOND YEAR.

SIXTH GRADE.

PART I—CARVING.

LESSON XXIV.

HORIZONTAL AND VERTICAL LINES.

In the following carving lessons it is desirable to use $\frac{1}{8}$ in. soft wood, and basswood is preferable, because it is soft, white and cheap.

Problems to be executed in carving will be found on Plates V and VI, represented 2-5 size, and a scale of inches is given. Problems 24 to 31 require boards 4 in. x 2 in. All problems should be sketched on the blackboard and the pupils required to write out the successive steps. Each pupil should be supplied with a small drawing board, T square, 45° and 60° triangles, before taking up this year's course. In the absence of such an outfit let the pupils make basswood triangles, $\frac{1}{8}$ in. thick, from drawings shown in Problem 42, Plate VII, using them in connection with the school rule for a straight edge.

In beginning Lesson XXIV take a board 4 in. x 2 in. x $\frac{1}{8}$ in. and draw lines on one side of it, with a finely-pointed pencil, dividing it in $\frac{1}{2}$ in. squares, as in Fig. 106.

FIG. 106.

In drawing the lines which run crosswise use the try-square. In drawing the lines which run lengthwise, make points at every $\frac{1}{2}$ in. along each end, and use the straightedge. It is not best to use the scratch gauge. All lines for carving should be pencil lines. Carve to the lines which run crosswise. See that the knife has a thin point and keen edge. Hold the knife as in Fig. 32, and let it just touch the right-hand side of the pencil line, while it is drawn entirely across the board. Turn the board end for end, and cut close to the opposite side of the lines. We now have a succession of V grooves across the face of the board at every ½ in. Each groove should be less than 1-32 of an inch wide and about 1-64 of an inch deep. An edge view of the board will appear as in Fig. 107.

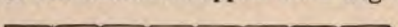


Fig. 107.

Carve the lengthwise lines in the same way. The thumb, in so long a cut will rest on the face of the board, a little in advance of the knife blade. Pupils who work rapidly may repeat the problem on the back of the board or on a new board.

See Problem 24, Plate V.

LESSON XXV.

OBLIQUE LINES.

Take a board 4 in. x 2 in. x ⅛ in. On one side of it make points at every ½ in. along each end, and along each edge. With finely-pointed pencil and straight edge draw oblique lines, as in Fig. 108.

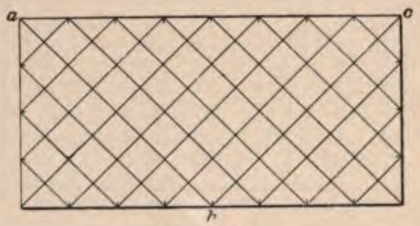


Fig 108.

Carve first all lines running in one direction, as the line *a b* and its parallels, then those crossing them, as *b c* and its parallels. Care will be needed in carving the second set of lines not to break the corners where the first set of lines is crossed. See Problem 25, Plate V.

LESSON XXVI.

GREEK FRET.

Take a board 4 in. x 2 in. x $\frac{1}{8}$ in. Draw fine lines lengthwise $\frac{1}{4}$ in. from each edge, and then draw lengthwise lines between them $\frac{3}{8}$ in. apart, as in Fig. 109.

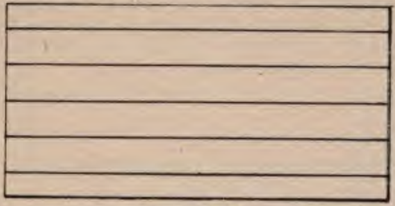


FIG. 109.

Draw fine lines crosswise $\frac{1}{8}$ in. from each end, and then draw lines between them $\frac{3}{8}$ in. apart, as in Fig. 110.

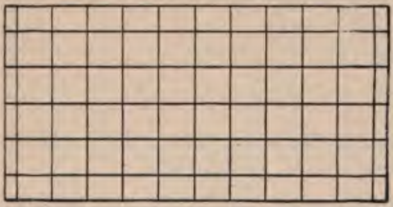


FIG. 110.

Redraw heavier such parts of these lines as are so drawn in Fig. 111.

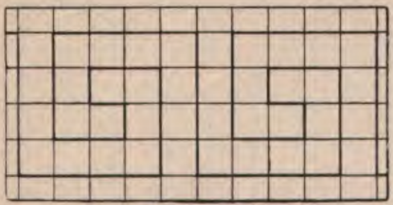


FIG. 111.

Carve to these heavily-drawn lines. See Problem 26, Plate V.

LESSON XXVII.

DIAGONAL INTERLACING.

Take a board 4 in. x 2 in. x $\frac{1}{8}$ in. and make points every inch along the edges and ends, as in Fig. 112.

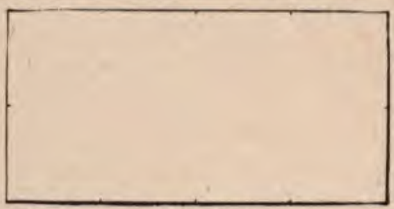


FIG. 112.

Make points 1-16 in. each side of above points, also from each corner of the board, as in Fig. 113.

FIG. 113.

Connect the last-made points by fine oblique lines, as in Fig. 114.

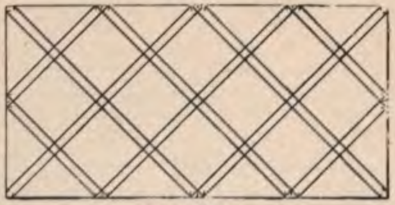


FIG. 114.

Erase such short portions of these oblique lines as should be dispensed with, in order to give the work the interlaced appearance of Problem 27, Plate V. Carve to the lines which remain.

LESSON XXVIII.

CONCENTRIC ARCS.

Take a board 4 in. x 2 in. x ⅛ in. Draw lines ¼ in. from each edge and from each end forming a rectangle as in Fig. 115.

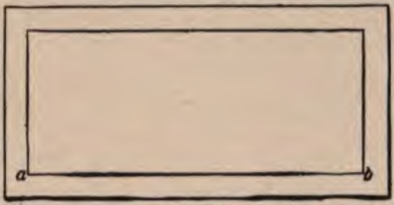


Fig. 115.

On the line *a b* make points at every ¼ in., as in Fig. 116.

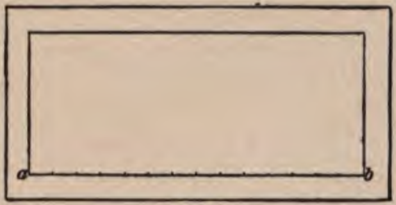


Fig. 116.

With the point *a* for a center, and with the dividers set so as to reach each of the other points successively, describe arcs, as in Fig. 117.

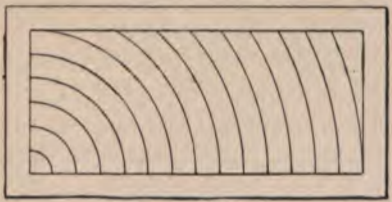


Fig. 117.

Carve to the lines of the rectangle and to these arcs. See Problem 28, Plate V.

LESSON XXIX.

WAVE SCROLL.

Take a board 4 in. x 2 in. x $\frac{1}{8}$ in. Upon drawing paper construct a rectangle 4 in. x 2 in. Within this construct another rectangle 3-16 in. from each side. Through the center draw a horizontal line and a vertical line, point off 13-16 in. to the right of *a* and *b*, and mark these points *c* and *d* as in Fig. 118.

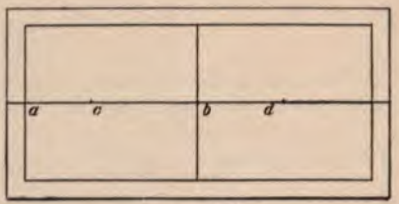


FIG. 118.

Begin at *c* and draw the scroll *c h i*, escaping the lower side of the rectangle by $\frac{1}{8}$ in. at the point *h*. Next draw the scroll *c f g*, escaping the upper side of the rectangle by $\frac{1}{8}$ in. at the point *f*, as in Fig. 119.

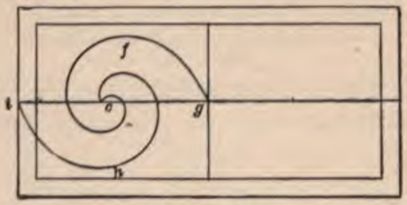


FIG. 119.

In the same way draw the scroll in the other half of the rectangle. Cut this drawing from the paper to its outline, place impression paper under it and pin both to the board with the edges of the drawing corresponding with the edges of the board, and with either a finely-pointed pencil or a sharpened stick trace the drawing, except construction lines, on the board. Remove the paper and carve to the lines. See Problem 29, Plate V.

LESSON XXX.

ECHINUS OR EGG, AND DART.

For this lesson take a board 4 in. x 2 in. x ⅛ in. Upon drawing paper construct a rectangle 4 in. x 2 in. Within this construct another rectangle ¼ in. from long sides and ⅛ in. from short sides. Divide the inner rectangle into six equal spaces by drawing five verticals, as in Fig. 120.

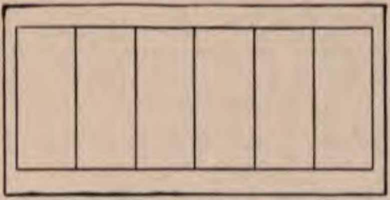


Fig. 120.

In each double space draw segments of ovals, as in Fig. 121.

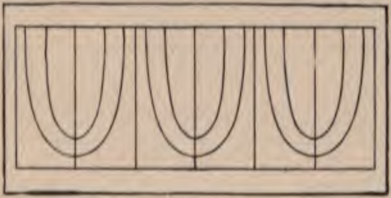


Fig. 121.

Each larger oval in its widest part escapes the verticals on each side by ⅛ in. and the lower line by 3-16 in. Each smaller oval is 3-16 in. within the larger oval. These measurements should be made by the eye, and not by the rule. Draw the dart shape between the large ovals, as in Fig. 122.

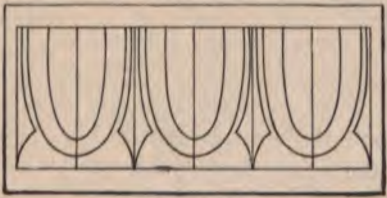


Fig. 122.

Cut this drawing from the paper, and with impression paper trace it, except the construction lines, on the board, as in the last lesson. Remove the paper and carve to the lines. See Problem 30, Plate V.

LESSON XXXI.

GUILLOCHE.

For this lesson take a board 4 in. x 2 in. x $\frac{1}{8}$ in. Upon drawing paper construct a rectangle 4 in. x 2 in. Within this draw another rectangle $\frac{1}{8}$ in. from long sides and $\frac{1}{4}$ in. from short sides. Draw horizontal lines 1-16 in. from the long sides of the inner rectangle, a horizontal line through the center and three verticals $\frac{7}{8}$ in. apart, as in Fig. 123.

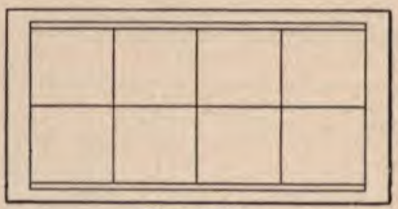


FIG. 123.

With the points *a* *b* and *c* as centers describe one circle and two semicircles $\frac{5}{8}$ in. in diameter, as in Fig. 124.

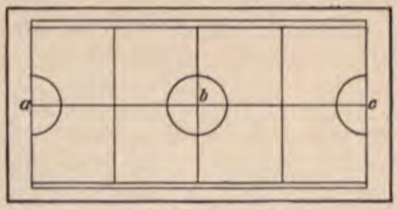


FIG. 124.

Draw free-hand the curve shown in Fig. 125, touching the under side of the circle described around *b* and touching the line *d e*.

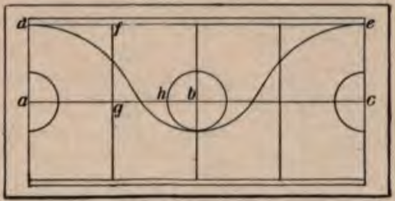


FIG. 125.

Notice that this curve crosses the vertical line *f g* near its middle point and the horizontal line *g h* near its middle point. Draw free-hand a curve opposite this one, as in Fig. 126. Notice that these two curves cross each other on the middle horizontal line.

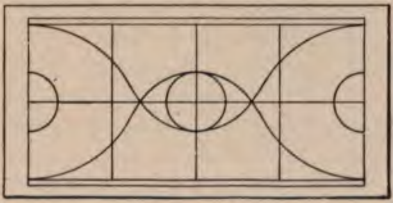


FIG. 126.

Draw two curves parallel to the two already drawn. Notice that these curves cross those drawn in Fig. 126 on the vertical lines *i j* and *k l*, and that they cross each other on the line *a c*, as in Fig. 127.

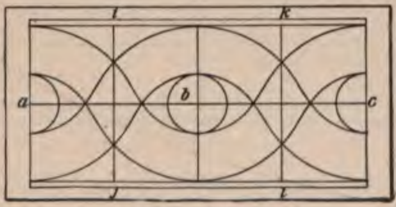


FIG. 127.

Complete the sketch by drawing curves parallel to and $\frac{1}{8}$ in. from the four curves just drawn, as in Fig. 128.

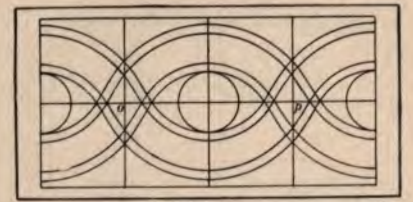


Fig. 128.

At *o* and *p*, where the curves cross, erase the lines which are drawn down toward the left and leave undisturbed the lines which are drawn down toward the right. See Problem 31, Plate V. Cut this drawing from the paper and with impression paper trace it, omitting construction lines on the board, as in Lesson XXIX. Remove the paper and carve to the lines.

LESSON XXXII.

DIAMOND BORDER.

This and the five succeeding lessons, the problems for which will be found on Plates V and VI, are executed on boards 8 in. x 2 in. x $\frac{1}{8}$. in. Take such a board and on it construct two rectangles 3-16 in. and $\frac{1}{4}$ in. respectively from its edges and ends. Divide the inner rectangle into six equal parts by vertical lines, and draw a horizontal line along the middle, as in Fig. 129.

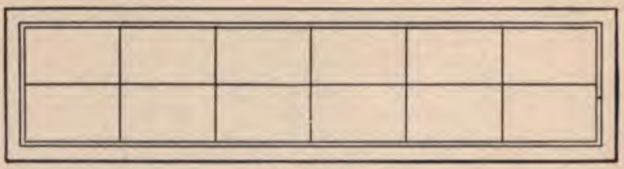


Fig. 129.

Beginning at the right hand, draw oblique lines from the ends of each vertical to the middle point of next vertical to the left; also draw similar lines halfway to the middle point of the next vertical on the right, as in Fig. 130.

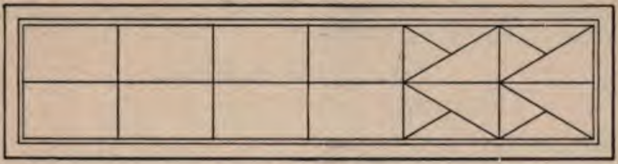


FIG. 130.

Carve to the oblique lines, to the outer rectangle and to the short sides of the inner rectangle. See Problem 32, Plate V.

LESSON XXXIII.

SHIELDS.

Take a board 8 in. x 2 in. x $\frac{1}{8}$ in. Construct a rectangle on it 3-16 in. from its edges and ends. Draw a horizontal line along the middle of the rectangle, make points 1-16 in. from each end and draw a vertical line, *a b*, through the left point. Between these two points on the horizontal line place points at every $\frac{3}{4}$ in., as in Fig. 131.

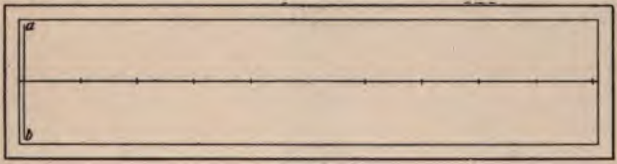


FIG. 131.

Set the dividers at $\frac{3}{4}$ in. and describe arcs of circles from each point of division on the middle horizontal line, beginning at the left and proceeding toward the right, as in Fig. 132.

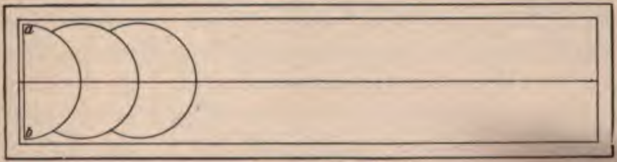


FIG. 132.

With dividers set successively at $\frac{5}{8}$ in., $\frac{3}{8}$ in. and $\frac{1}{4}$ in. radii, describe other arcs from the same centers, giving the drathe appearance of Problem 33, Plate VI. Carve to the arcs, to the line *a b* and to the rectangle.

LESSON XXXIV.

ELLIPSE AND LOTUS LEAF.

Take a board 8 in. x 2 in. x $\frac{1}{8}$ in. Draw on paper a rectangle 8 in. x 2 in. Within this draw two other rectangles 3-16 in. and $\frac{1}{4}$ in. respectively from the sides of the first. Draw a horizontal line along the middle of the inner rectangle, and draw verticals crossing it at every $\frac{5}{8}$ in., as in Fig. 133.

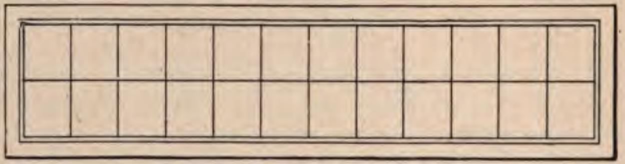


Fig. 133.

With each vertical line as a long diameter draw an ellipse, the short diameter of which shall be two sections of the middle horizontal line, as at A in Fig. 134.

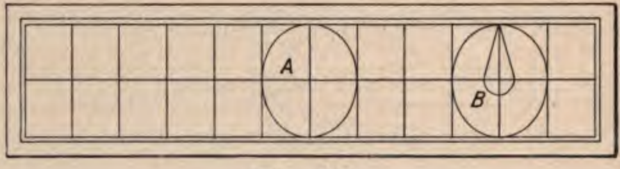


Fig. 134.

Around the center of each ellipse describe free-hand, a 5-16 in. semicircle below the middle horizontal line, continuing the circle slightly above the line, and from its extremities draw straight lines to the upper end of the long diameter, as at B in Fig. 134. We call this last-described part of the drawing a lotus leaf. Erase such part of the ellipses as are hidden by the leaf. See Problem 34, Plate VI. Cut this drawing from the paper and with impression paper trace it on the board, as in Lesson XXIX. Trace the lotus leaves and such parts of the ellipses as are exterior to them; also trace the outer rectangle and the short sides of the inner rectangle. Remove the paper and carve to the lines. See Problem 34, Plate VI.

LESSON XXXV.

WAVE LINE AND SCROLLS.

Take a board 8 in. x 2 in. x $\frac{1}{8}$ in. On a sheet of drawing paper construct a rectangle 8 in. x 2 in. Draw horizontal lines 3-16 and $\frac{1}{4}$ in. from each long side, also along the middle. Draw vertical lines at every inch, touching the inner horizontal lines, as in Fig. 135.

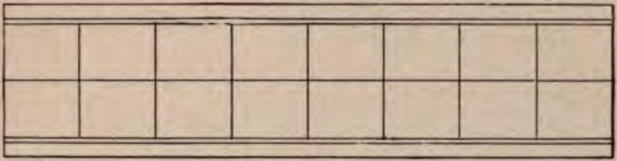


FIG. 135.

Draw a continuous curve or wave line, as in Fig. 136.

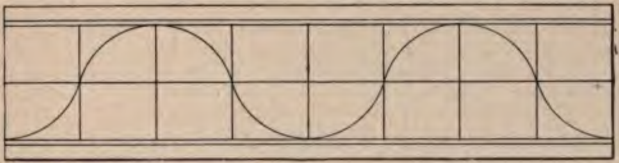


FIG. 136.

Draw the large scroll as at A in Fig. 137; then add the small curves at B, noticing where the different parts of the curves cross or touch the vertical or horizontal lines.

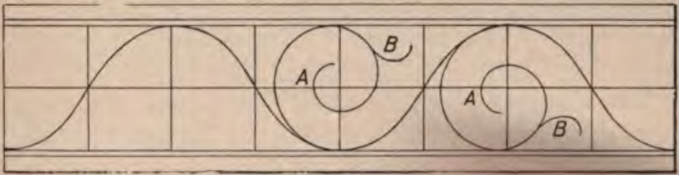


FIG. 137.

When the drawing is complete, cut it from the

with impression paper trace it upon the board

XXIX. Trace the curve and scrolls and the outer horizontals. Remove the paper and carve to the lines. See Problem 35, Plate VI.

Pupils who work rapidly may add leaves to the curves and carve them.

LESSON XXXVI.

BLOCK LETTERS.

Take a board 8 in. x 2 in. x $\frac{1}{8}$ in. Construct a rectangle on it $\frac{1}{8}$ in. from its edges and ends. Within this draw lines $\frac{1}{4}$ in. apart each way, as in Fig. 138.

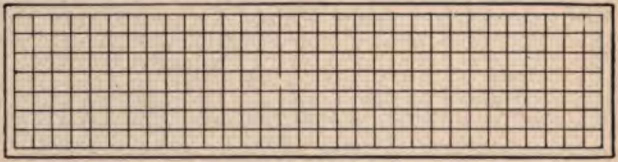


FIG. 138.

Upon this draw six letters, as in Fig. 139.

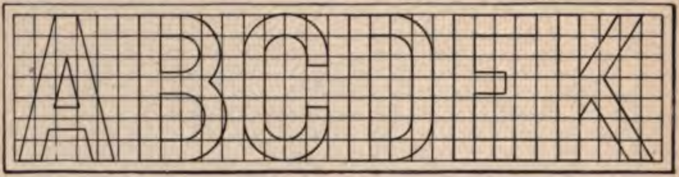


FIG. 139.

Carve these letters. See Problem 36, Plate VI. Reference to Plate IV, with instructions given in Lessons XXI, will show the method of drawing any block letter.

LESSON XXXVII.

SCRIPT CAPITAL LETTERS.

Take a board 8 in. x 2 in. x $\frac{1}{8}$ in., and let each pupil write on it his own initials and carve them. See Problem 37, Plate VI.

Notice the shaded portions and carve them to a depth proportional to their width; also make round periods. Practice making periods on waste board first. This series of carving lessons can be extended indefinitely by adding other interesting designs.

SECOND YEAR.

SIXTH GRADE.

PART II—SURFACE FORMS,

CUT FROM THICK WOOD.

LESSON XXXVIII.

TO MAKE A SQUARE OF THICK WOOD.

As a preliminary to this lesson, provide each pupil with a basswood board 16 in. long x 7 in. wide 5-16 in. thick, which will be used in the following lessons according to the diagram in Fig. 140. The portion marked 1 is to be used in Lesson XXXVIII, the portion marked 2 as in Lesson XXXIX, and so on.

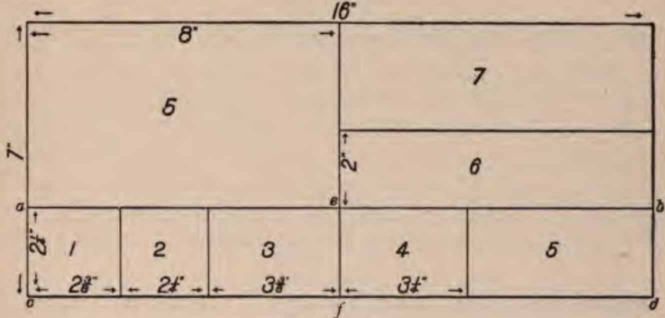


Fig. 140.

Rough cut from it a strip 2 ¼ in. wide as follows: Set the gauge 2 ¼ in. and gauge from one edge of the board the lines *a b*, on both sides. Draw the large blade of the knife through these gauged lines a few times, when the board will split along the line, severing the strip *a b c d* from the rest of the board. Cut this strip in two equal lengths on the line *e f*. Straighten an edge of the portion *a e f c* as follows: With finely-pointed pencil and straightedge draw a line on one side near or edge; square across each end at the extremities of this and draw a line on the other side of the board joinin lines, as at *a b c d* in Fig. 141.

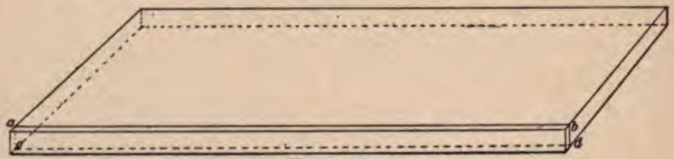


FIG. 141.

Cut first to the line *a b*, taking care not to injure the line *c d*, when the board will appear as in Fig. 142.

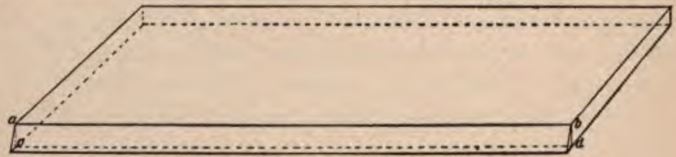


FIG. 142.

Next cut in a similar way to the line *c d*. The raised portion *e o*, shown in Fig. 143, should be as slight as possible.

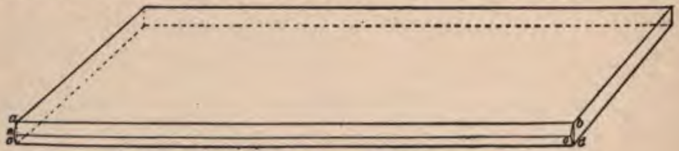


FIG. 143.

Finally remove the surplus wood *e o*, leaving the edge square across from the line *a b* to the line *c d*, as in Fig. 144.

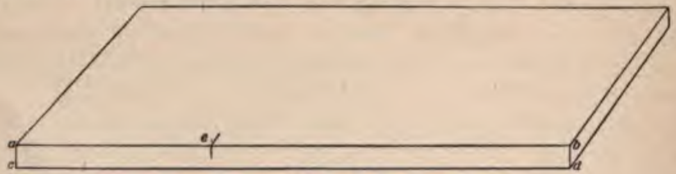


FIG. 144.

The above description illustrated in Figs. 142, 143 and 144 is a triple application of the fundamental Rule IV, and should be observed in the lessons which follow. Mark this edge as at *e* in Fig. 144. This mark is mentioned in Lesson VII. It is known as a tried mark, and is used to denote the standard side and edge from which the gauging and squaring are to be done.

Another method of drawing a line on the second side of the board, to insure its being opposite the first line drawn, is to cut to the first line for a distance of about ¾ in. at each end, testing with try-square to get the cutting square with the face, as at *a* and *b* in Fig. 145.

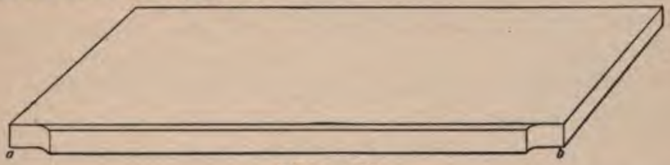


FIG. 145.

Then draw a fine line on the other side, touching the places cut.

To make a 2 in. square of thick wood take the true-edged piece described above, square around and cut off one end as directed in Lesson VII, cutting halfway through from one side, then turn the board over and cut the remainder from the opposite side. Pupils must bear in mind the instructions given in connection with Figs. 142, 143, 144. Measure from the finished end 2 in. plus, (see Lesson VII) and square around and cut off the board in the same way; make the board 2 in. wide as directed in Lesson VII, also observing the triple application of Rule IV mentioned above. It will be seen that the order of working in making a board 2 in. square of thick wood is the same as for thin wood, namely: True an edge; make the opposite edge parallel with it; square an end; make the second end the correct distance from the first. Two views of the finished square are shown in Problem 38, Plate VII.

It will be noticed that frequent reference is made to Lesson VII, and also to instructions given in connection with Figs. 142, 143 and 144, in all the lessons which follow. It is verg important that these instructions be constantly recalled and faithfully observed by pupils in every lesson.

LESSON XXXIX.

TO MAKE A CIRCLE OF THICK WOOD.

From the strip straightened in Lesson XXXVIII cut off roughly a piece about 2 ¼ in. long. Square a line around the middle of it with finely-pointed pencil. When the try-square beam has so short a bearing against the edge of the board as in this case it is well to draw the pencil along the inner edge of the try-square blade. Set the gauge 1 and 1-16 in., and gauge on this line from the trued edge a point on each side of the board. It is evident that these points will be directly opposite each other. Fig. 146 shows one side of the board so marked.

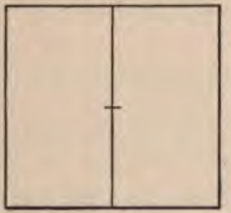


FIG. 146.

With dividers set 1 in. and with these points as centers, describe a circle on each side of the board. Recall Rule III, and cut roughly near to the circles, and then recall Rule IV and cut exactly to them. When practicing Rule IV observe triple application as directed in the previous lesson. Two views of the finished circle are shown in Problem 39, Plate VII.

LESSON XL.

TO MAKE AN ELLIPSE OF THICK WOOD.

Take the remaining portion of the strip straightened in Lesson XXXVIII, and with finely-pointed pencil square two lines around it, 3 in. apart. With gauge set 1 and 1-16 in. gauge points on these lines as in the previous lesson. Each side of the board will appear as in Fig. 147; *a* and *b* are the gauged points.

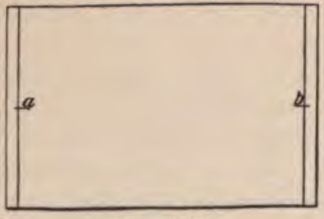


FIG. 147.

Make from cardboard an elliptical templet. Lesson XIV, defines a templet, and Lesson XIII, gives directions for describing an ellipse. By means of this templet draw an ellipse on each side of the board, using the points *a* and *b*, Fig. 147, as the corresponding points *a* and *b*, Fig. 55, were used to guide the templet.

Cut as in the last lesson, that is, observe Rule III, "Cut near to line," and Rule IV, "Cut exactly to line," making three divisions of Rule IV, as in the last lesson. Two views of the finished ellipse are shown in Problem 40, Plate VII.

LESSON XLI.

TO MAKE AN OVAL OF THICK WOOD.

Take the part of the stock board *e b d f*, Fig. 140, straighten one edge of it and cut off roughly a piece 3 ¼ in. long. The directions given for Lesson XL are sufficient for this lesson, the only difference being in making an oval templet, instead of an elliptical one. Two views of the finished oval are shown in Problem 41, Plate VII.

LESSON XLII.

DRAFTING BOARD, T SQUARE AND TRIANGLES.

From the part of the stock board which remains, (see large portion marked 5, Fig. 140), make a board 7 in. x 4 in., following directions given in previous lessons. This will constitute a drafting board. Make also from the small portion marked 5 a piece 2 in. x ¾ in. for a T square head, and from ⅛ in. stock make a piece 8 in. x ¾ in. for a blade. Fasten the blade to the head with four ⅜ in., No. 22, steel-wire brads. To insure the blade being square with the head, first drive one brad at *a*, Fig. 148, and then hold the two pieces against the try-square

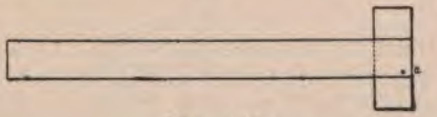


FIG. 148.

as in Fig. 149, while brads are driven at b and c. Remove the try-square before driving the fourth brad, to avoid danger of injuring the square with the hammer.

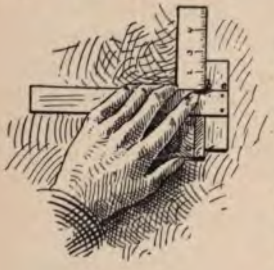


Fig. 149.

Two views of the drafting board are shown at A and B, Problem 42, Plate VII, two views of the T square at C and D, and two triangles at E and F, lying on the drafting board. The triangles are made from $\frac{1}{8}$ in. basswood. The triangle E is right-angled at c, and the sides $a\ c$ and $b\ c$ are both 2 in. long. The angles at a and b are each 45° and the implement is known among draftsmen as a 45° triangle. The triangle F is right-angled at f. The side $d\ f$ is 2 in. long and the side $e\ d$ is 4 in. long. A triangle so made will have the angle e 30° and the angle d 60°, and is known as a 30° and 60° triangle. If four 45° triangles, made by four different pupils, are placed together with the right angles at a given point, they should appear as in Fig. 150.

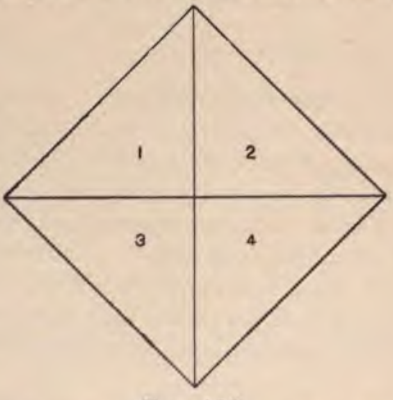


Fig. 150.

If six 30° and 60° triangles, made by six different pupils, are placed together with the 30° angles at a given point, they should appear as in Fig. 151, the two outside triangles 1 and 6 *meeting the straightedge* $a\ b$. It will interest and stimulate

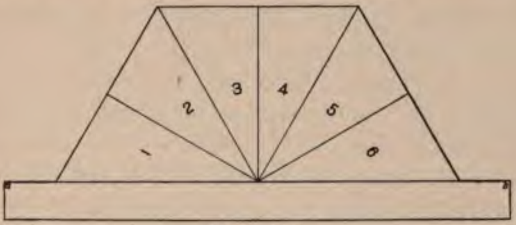


FIG. 151.

pupils to test their triangles in these ways. T squares may be tested with the standard try-square.

LESSON XLIII.

TO MAKE A FLIGHT OF STEPS.

Problem 43, Plate VIII, shows three views, A B C, of a flight of steps. The end pieces shown in full at B, are called stringers, *m n* and *o* are called treads, *a e* and *i* are called risers. Place upon the blackboard the drawing of a flight of steps with dimensions, as in Fig. 152.

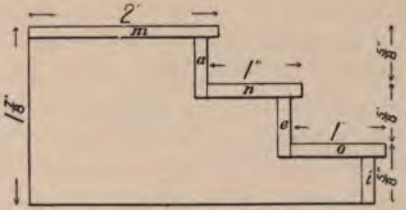


FIG. 152.

It will be seen from Fig. 152 that each step is $\frac{5}{8}$ in. high, the top tread *m* is 2 in. wide, and the other two treads *n* and *o* are each 1 in. wide. The treads are $\frac{1}{8}$ in. thick, as are also the risers *a*, *e* and *i*, and each tread projects $\frac{1}{8}$ in. in front of its riser. Draw a stringer on the blackboard as in

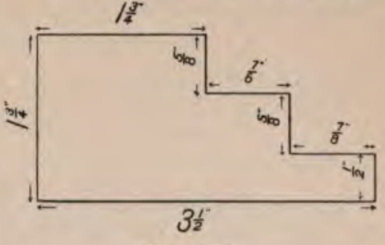


FIG. 153.

Fig. 153, without dimensions. These may be written down when they are determined by the pupils.

Let each pupil fasten a piece of drawing paper to his drawing board made in the last lesson, using four 1 oz. tacks, and draw the stringer, using his T square and triangles just made. Have him study out the dimensions of the stringer from Fig. 152, and as he determines them, write them on his drawing.

Straighten one edge of that portion of the stock board which is marked 6, Fig. 140, and make two pieces 3½ in. long, working as in previous lessons. Set the gauge at 1¾ in. Gauge on both sides of these boards and finish to that width. Each piece will appear as in Fig. 154.

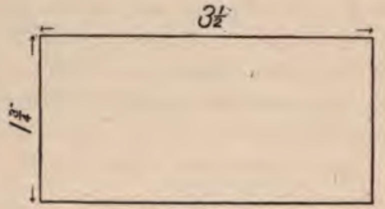


Fig. 154.

Lay out both sides of both boards, as in Fig. 155, using gauge, try-square and knife.

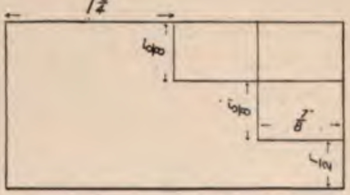


Fig. 155.

Cut out the upper right-hand corner, leaving the work as in Fig. 156; then cut out the corner D, to complete the stringers. Work in detail as previously directed.

An inspection of A, Problem 43, Plate VIII, shows that the ends of the treads project ⅛ in. beyond the stringers, while the ends of the risers are even with the outside of the stringers. The treads are 4 in. long, hence the risers must be 3 ¾ in. long. This figuring should also be done by pupils and measurements set down on paper, as follows :—

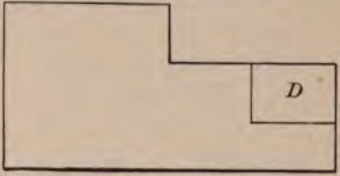


Fig. 156.

One tread, 4 in. x 2 in.
Two risers, 3 ¾ in. x ⅝ in.
Two treads, 4 in. x 1 in.
One riser, 3 ¾ in. x ½ in.

Supply the class with ⅛ in. basswood, and let each pupil make a set of treads and risers according to instructions given in Lesson VII. When all is complete nail first the risers to the stringers, putting two ½ in. No. 21, steel-wire brads in each end of each riser, and taking care to have all parts properly joined. Nail on the lower riser first, then the upper, and lastly the middle one. The work will be easier and more certain of coming together correctly, if this order is observed.

C, Problem 43, Plate VIII, is a plan view of the flight of steps and shows the number and position of the brads in the treads. Use ⅜ in. No. 22, steel-wire brads to fasten the treads to the risers and stringers. Nail the lowest tread first, then the middle one, and lastly the upper one. The object of this order is that the projection of an upper tread may not be in the way of the hammer while nailing a lower tread. Be careful to have the two ends of each tread project equally beyond the stringers.

LESSON XLIV.

TO CUT A SQUARE HOLE THROUGH THICK WOOD.

Rough out a piece 2 ¼ in. square from the stock board remaining. Finish it to a 2 in. square. Set the gauge 5-16 in. and gauge from the edges on both sides of the board, taking care not to approach the ends nearer than 5-16 in., as in Fig. 157.

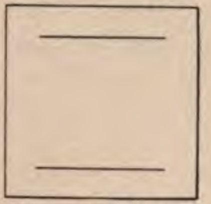


FIG. 157.

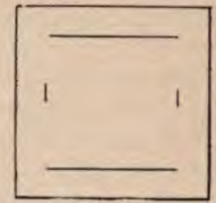


FIG. 158.

On one side of the board measure 5-16 in. from each end as in Fig. 158.

Use knife and try-square, and square lines through these points as in Fig. 159, recalling instructions in connection with Fig. 26, and Fig. 144. Make crosswise knife lines like *a b* and *c d* on the opposite side of the board, by placing slight cuts near the corners of the tried-edge, as at *e*, *e* Fig. 160. Use the knife and try-square, and be sure that the lines are exactly opposite.

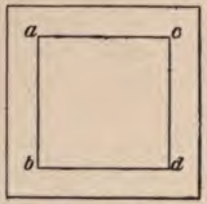


FIG. 159.

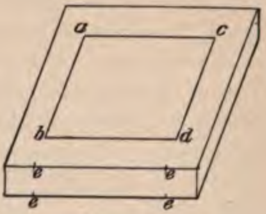


FIG. 160.

Cut to the lines on one side of the board, first drawing the knife through each line and then cutting obliquely near to it as in Fig. 32. Repeat these alternate cuttings until the depth of the cut reaches halfway through the board, then turn the board over and cut the remainder from the other side. Recall the directions concerning the triple applications of fundamental Rule IV, in Lesson XXXVIII. The finished work will be a square frame. See Problem 44, Plate VIII.

LESSON XLV.

TO CUT A ROUND HOLE THROUGH THICK WOOD.

From the stock board remaining, make a 2 in. square as in the previous lesson. Square a fine pencil line around the middle and with gauge set at 1 in. make points opposite each other on the sides of the board, as in Lesson XXXIX. With these points as centers and a radius of 11-16 in. describe a circle on each side of the board. Cut on one side to the circle about halfway through the board, as in Lesson XLIV, and then on the other side.

For two views of a square block having a round hole, see Problem 45, Plate VIII. If extra work is desired pupils may make the outside of the board round.

LESSON XLVI.

TO CUT AN ELLIPTICAL HOLE THROUGH THICK WOOD.

Make a board 3 in. x 2 in. Draw a line lengthwise along the middle of one side, and make points on this line 5-16 in. from each end as at *a* and *b* in Fig. 161.

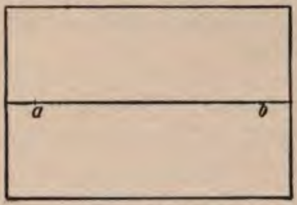


FIG. 161.

These points will be $2\frac{5}{8}$ in. apart and are to be extremities of the long diameter of an ellipse. Find points opposite on the other side of the board, by squaring around, using a finely-pointed pencil. Make an elliptical templet $2\frac{5}{8}$ in. x $1\frac{3}{8}$ in., as in Lesson XL, and with it describe an ellipse on each side of the board. Cut to the lines about halfway through the board on one side and then on the other, as in previous lessons. For two views of an oblong block with an elliptical hole, see Problem 46, Plate VIII. Pupils who work rapidly can make the outside of the board elliptical. An hexagonal board may be made with an hexagonal hole, and an octagonal board with an octagonal hole.

LESSON XLVII.

RECTANGULAR PICTURE FRAME.

Problem 47, Plate IX, shows a rectangular picture frame. Take a board 7 ½ in. x 6 in. x 5-16 in., draw lines lengthwise on it 1 ½ in. from each edge and crosswise 1 ½ in. from each end. Lay out both sides of the board in this way and cut to the lines halfway through on one side and then on the other side, so as to make an opening through the board, following directions given in Lesson XLIV. This opening will be large enough for a cabinet photograph. Set the gauge 1 ⅜ in. and ⅛ in. successively and gauge very lightly on the front side of the board from its ends and edges.

Set the gauge ⅛ in. and gauge from the front side on the ends and edges of the board and on the ends and edges of the opening. Cut away the corners to these lines. This cut is called a chamfer. The work will then appear as in Fig. 162. A is a sectional view.

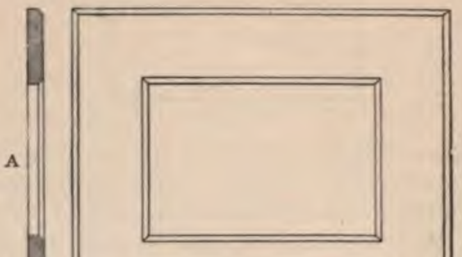


Fig. 162.

The wood which remains around the opening is called a molding. The design to be carved is drawn on the middle of the molding. Draw a 1 in. square on each corner, and connect these squares by parallel straight lines ⅝ in. apart, as in Fig. 163.

Pupils may complete the work by carving to these lines, or advanced pupils may add the ribbon design shown on one half of Problem 47, Plate IX.

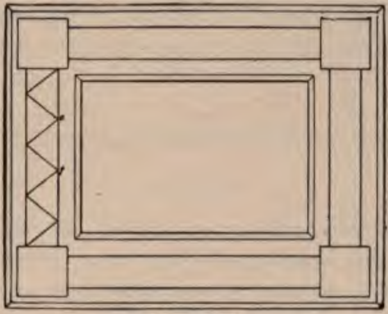


Fig. 163.

The lines to be drawn first in the ribbon design are shown in Fig. 163, and the distance between the points *e* and *f* and corresponding points is 1 in. Pupils who have not time for the ribbon design may carve a simple corner design, as in Fig. 164.

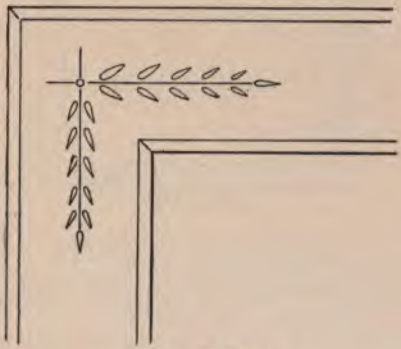


Fig. 164.

Make a pocket for the back side of the frame to hold the picture as follows: Take $\frac{1}{8}$ in. stock, and make two pieces 7 $\frac{1}{2}$ in. long x $\frac{1}{2}$ in. wide and one piece 5 in. x $\frac{1}{2}$ in. Set the gauge $\frac{1}{8}$ in. and gauge a line on one side of each strip. Set the gauge 1-16 in. and gauge a line on the adjacent edge. Draw the knife point alternately along these lines until the piece enclosed by them is removed. This cutting is called a rabbit. The work will then appear as in Fig. 165.

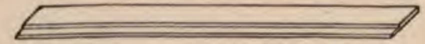


FIG. 165.

Nail these three pieces to the back of the frame, using $\frac{3}{8}$ in. No. 22, steel-wire brads, as in Fig. 166. Insert the picture in the opening at A, the top of the pocket.

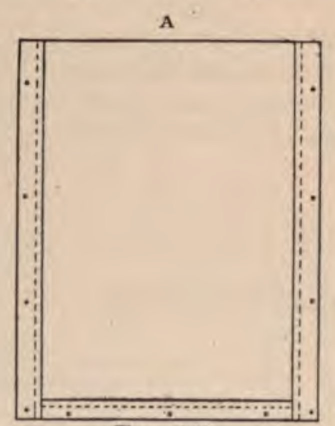


FIG. 166.

LESSON XLVIII.

ELLIPTICAL PICTURE FRAME.

Take a board 7 $\frac{1}{2}$ in. x 6 in. x 5-16 in. On each side of the board draw a vertical and a horizontal line crossing in the center. On these two lines as diameters describe an ellipse, following directions given in Lesson XL, and place a point at *b* 1 $\frac{1}{4}$ in. from the center, and the work will appear as in Fig. 167.

Draw a line through *b* parallel to the long diameter, and on this line describe an ellipse 3 ¼ in. x 2 ⅛ in., as in Fig. 168.

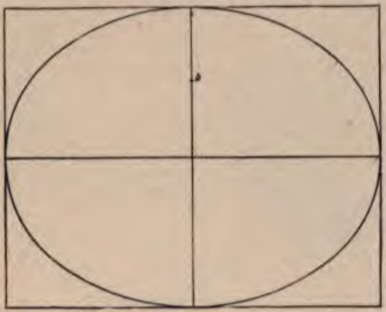


FIG. 167.

Cut to the lines of the large ellipse, as in Lesson XL, and then cut to the lines of the small ellipse, as in Lesson XLVI.

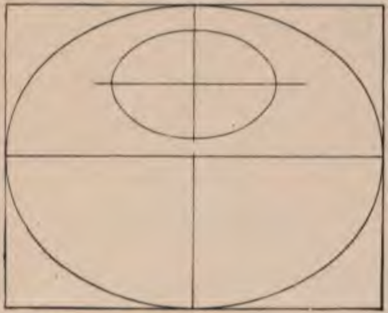


FIG. 168.

On the front side of the board draw lines ⅛ in. from the edges of the ellipses. This is done with dividers, holding them as in Fig. 169. This use of dividers is called scribing.

If the dividers used will not admit of the points being brought near enough together, as is the case with some school dividers, a little skill will be required to hold them at a proper angle, so as to scribe ⅛ in. See Fig. 170, where the two points, though ¼ in. apart, are held at such an angle as to scribe ⅛ in.

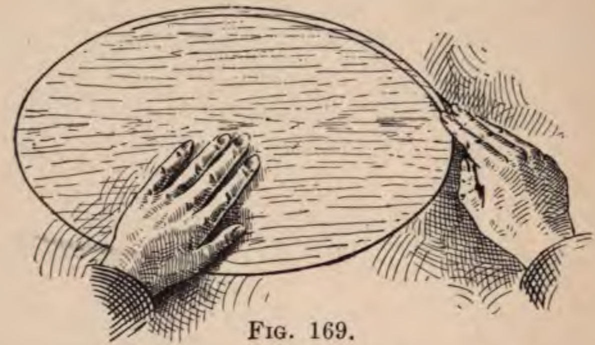


FIG. 169.

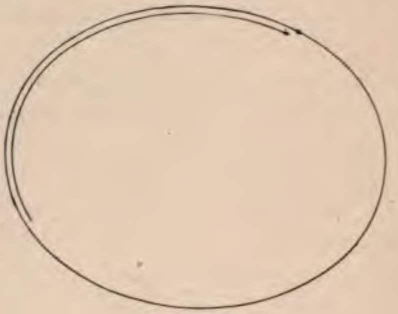


FIG. 170.

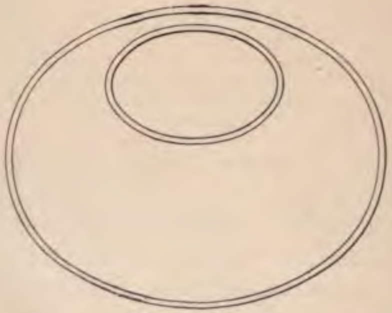


FIG. 171.

The work will appear after these lines are scribed, as shown in Fig. 171.

In a similar way scribe lines on the edges of both ellipses. Chamfer to these lines, as in the previous lesson. On the face of the board draw the design shown in Problem 48, Plate IX, or some other suitable design, and carve it. Four other designs are found on Plate X, which may be used for extra work.

To hold the picture, make a pocket from $\frac{1}{8}$ in. stock. Make one piece 4 $\frac{7}{8}$ in. x $\frac{1}{2}$, and two pieces 2 $\frac{1}{2}$ in. x $\frac{1}{2}$ in. Rabbit these pieces as in previous lesson, and nail to the back of the frame, as in Fig. 172. Insert the picture on the side A.

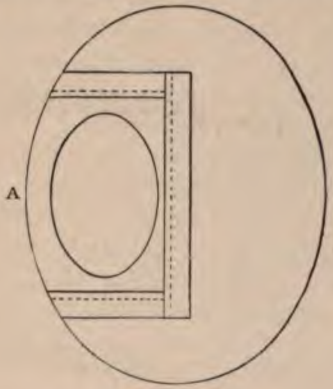


FIG. 172.

LESSON XLIX.

BOX FOR HOLDING THE WORK.

A box, 9 in. long x 5 in. wide x 3 $\frac{1}{4}$ in. high, outside measure, will hold the work of the second year, exclusive of the picture frames. Two views of such a box are shown in Problem 49, Plate VIII. The sides and ends are of 5-16 in. stock, and the top and bottom of the box are $\frac{1}{8}$ in. thick. Let the class figure out the sizes of the sides and ends and when found have them written on the board. The two sides will be found to be 9 in. long x 3 in. wide and the two ends 4 $\frac{3}{8}$ in. long x 3 in. wide.

Supply each pupil with sufficient wood 5-16 in. thick and have him cut four boards to the above sizes, following carefully all directions previously given. Nail them together as in making the box at the close of the first year, using 1 in. No. 18, steel-wire brads. Sandpaper the edges of the frame, true and make the bottom and cover the same as in the first year.

On Plates XI and XII will be found designs for ornamenting the top, sides and ends of this box, from which a choice can be made. For the design on Plate XI, draw five rectangles on the cover distant from the ends and edges 3-16 in., $\frac{1}{4}$ in., $\frac{5}{8}$ in., 1 in., and 1 and 1-16 in. respectively, and draw the design as in Lesson XXXII. Use T square and 30° triangle for the body of the work and the 45° and 30° triangle for the corner diamonds. Let each pupil carve his own initials in the middle of the cover. The design for the sides and ends will not require further detailed instruction.

For the design on Plate XII, draw two rectangles on the cover, distant from edges and ends $\frac{1}{2}$ and $\frac{3}{4}$ in. respectively, and draw the design shown, or any five-petaled flower, and carve to the lines. Two rectangles on the sides and ends of the box will be sufficient and appropriate. Fig. 173 is a more elaborate design for a box cover. A modification of it can be used for the sides and ends.

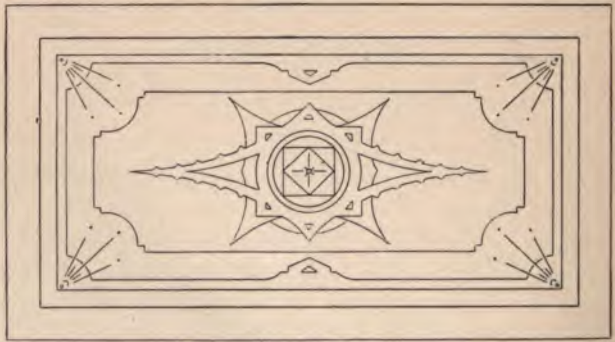


FIG. 173.

In place of any of these designs it would be well to allow pupils who can, to draw original designs and carve them.

THIRD YEAR.

SEVENTH GRADE.

PART I—GEOMETRIC SOLID FORMS.

LESSON L.

TO MAKE A SQUARE PRISM.

Before beginning each lesson in this series it will be well to teach the definition of the geometric form to be made. In order to shape a square prism supply straight-grained blocks of pine or basswood 3 in. long and split about 1 $\frac{1}{8}$ in square. True one side of the block, using the large blade of the knife, and testing as in Fig. 25. Test the work with the straightedge crosswise in three places, near each end and in the middle, as shown by dotted lines in Fig. 174.

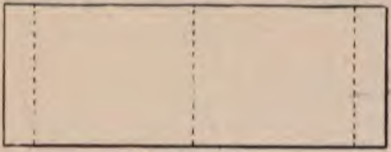


FIG. 174.

Then test lengthwise in three places, near each edge and in the middle, as shown by dotted lines in Fig. 175.

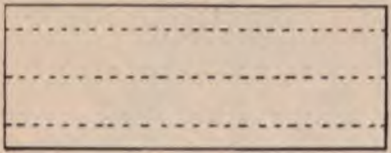


FIG. 175.

Cut off all high places indicated by these tests, at the same time keeping close watch of the cross tests shown in Fig. 174. Lastly test on the diagonals, as shown by dotted lines in Fig. 176.

Cut off high places as this test indicates. The finished surface must pass all of the eight tests. Have the pupil write his name on this finished face.

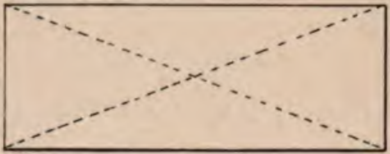


Fig. 176.

To finish the second side draw a line with pencil and straight-edge near one edge of the first side, as in Fig. 177.

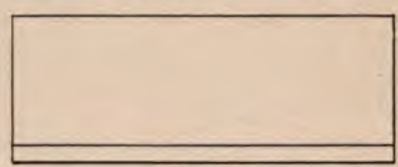


Fig. 177.

Cut the second side to this line, making the lengthwise and diagonal tests as mentioned above. The three cross tests are to be made as in Fig. 178, in order that the second face may be not only true, but also square with the first.

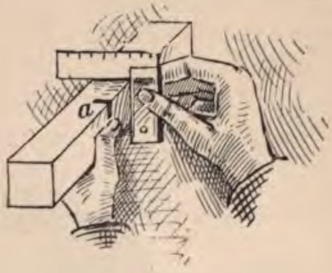


Fig. 178.

Mark the first and second faces as shown at *a*, Fig. 178. These are called "tried marks," and are used by joiners to designate the standard corner of finished timber. This mark has been once referred to in Fig. 26. To finish the third and fourth sides of the prism proceed as follows: Set the gauge $\frac{7}{8}$ in. plus, and gauge carefully from the first-made face, on the two adjacent sides and on both ends. The adjacent side which has not yet been cut may need a small amount of rough cutting before this gauge mark can be made. The work now appears as in Fig. 179.

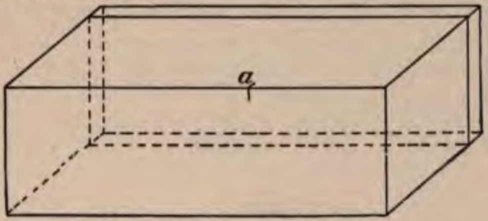


FIG. 179.

Cut away that portion of the block which is beyond the gauged lines, testing as in Figs. 174, 175 and 176. The third side of the prism is now parallel to the first side and $\frac{7}{8}$ in. from it. In the same way make the fourth side parallel to, and $\frac{7}{8}$ in. from the second side. Each face can be perfected, if desired, before making a subsequent face, by a careful use of sandpaper. Take half a sheet of No. 1 sandpaper, lay it on the desk-cover with rough side up, and hold the work down firmly, as in Fig. 180.

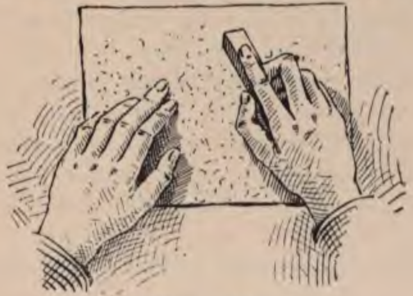


FIG. 180.

Move it slowly over the sandpaper, making as few motions as will suffice to smooth the irregularities, and move the work only in a direction from the place where the left hand holds the sandpaper, so as not to wrinkle the paper and unfit it for use.

To finish the ends first square around the sides near one end with knife and try-square. Place four points on this end at the middle of each side, and draw lines joining these points, as in Fig. 181.

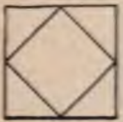


Fig. 181.

Cut to these lines, making successive cuts as in Fig. 66, until the lines are reached and the wood enclosed by them is removed, and the work will appear as in Fig. 182.

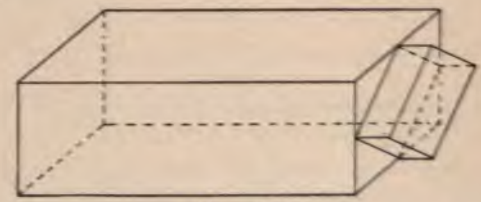


Fig. 182.

Place four points on the middle of each side of the uncut parts of the end and join them by straight lines. Cut to these lines as above, and the end will appear as in Fig. 183.

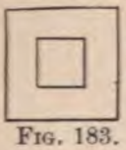


Fig. 183.

Place four points on the middle of each side of the uncut portion of the end, join these points by straight lines, and cut to them as before. So continue until the center is reached, when the end will be cut off true. Measure from this finished end $2\frac{1}{2}$ in. and cut the second end like the first. Problem 50, Plate XIII, shows a perspective view of the finished prism.

LESSON LI.

TO MAKE A CUBE.

Make a square prism as in the previous lesson, finishing only one end. Square around $\frac{7}{8}$ in. from this end, using the knife. Place points on the squared line at the center of each side and place points on the corners 1 ⅜ in. from the end. Join these points to points first made by straight lines. Cut to these lines, making successive cuts, as in Fig. 66, and the work will appear as in Fig. 184.

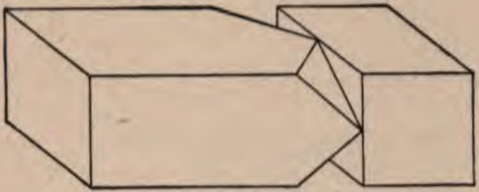


Fig. 184.

Finish the cube by following the successive steps described in the previous lesson. Problem 51, Plate XIII, shows a perspective view of the cube.

LESSON LII.

AN EQUILATERAL TRIANGULAR PRISM.

Take a finished block of wood 2 ½ in. x ⅞ in. x ⅞ in. With a pencil and the equilateral triangle made in Lesson IX draw a line on one end, as in Fig. 185.

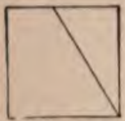


Fig. 185.

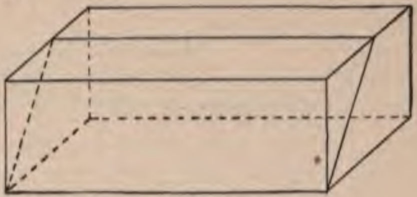


Fig. 186.

Draw a corresponding line on the opposite end, and gauge a line on the top joining the lines drawn on the ends, as in Fig. 186.

Cut away the wood outside of these two lines, referring to Figs. 142, 143 and 144, and the work will appear as in Fig. 187.

With pencil and equilateral triangle draw lines on the ends, and gauge between them on the newly-cut side, as in Fig. 188.

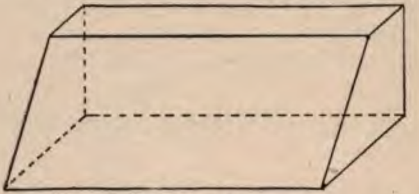


Fig. 187.

Cut away the wood outside of the lines as before. Finish the prism, if desired, by carefully using sandpaper as in Fig. 180. Problem 52, Plate XIII, shows a perspective view of the equilateral triangular prism.

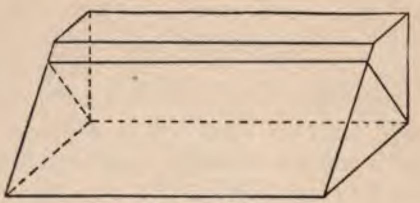


Fig. 188.

LESSON LIII.

TO MAKE AN HEXAGONAL PRISM.

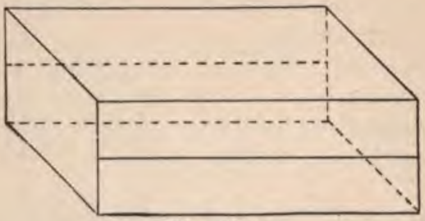


Fig. 189.

Take a piece of wood 2 ½ in. x 1 in. x ⅞ in. and draw a line along the middle of each ⅞ in. side, as in Fig. 189.

Set the gauge ¼ in. and gauge two lines on each 1 in. side, as in Fig. 190.

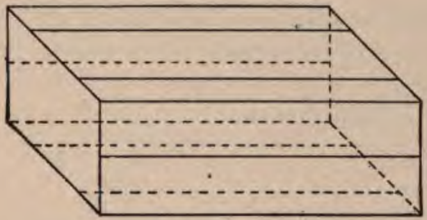


Fig. 190.

Join these lines by lines drawn on the ends, as in Fig. 191.

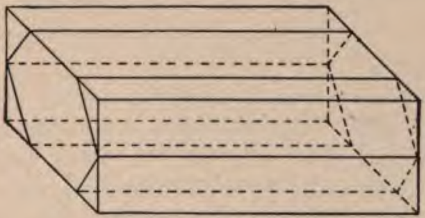


Fig. 191.

Cut to the lines as in the previous lesson. Problem 53, Plate XIII, shows a perspective view of the hexagonal prism.

LESSON LIV.

TO MAKE AN OCTAGONAL PRISM.

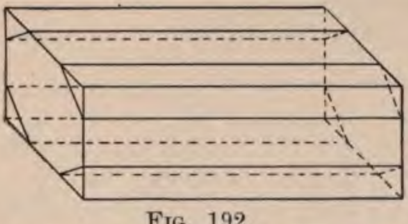


Fig. 192.

Take a block of wood 2 ½ in. x ⅞ in. x ⅞ in., draw an octagon on each end, as directed in Lesson X. Draw lines on every side joining the corners of the octagons drawn on the ends, as in Fig. 192.

These lines may be drawn with pencil and straightedge, or very fine lines may be gauged. Cut to these lines as in previous lessons. Problem 54, Plate XIII, shows a perspective view of the octagonal prism.

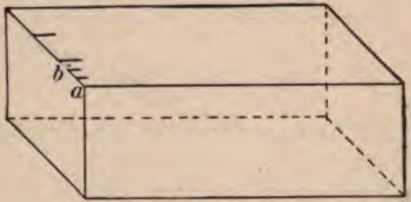


Fig. 193.

There are three methods of laying out an octagonal prism on a square block. For the second method, divide the end edge into three equal parts, and divide an end division into three equal parts, as in Fig. 193. Set the gauge two and one half of these parts, as *a b*. Gauge two lines on each side of the block.

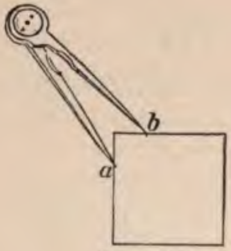


Fig. 194.

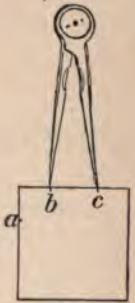


Fig. 195.

The third method is as follows: Set the dividers a little more than $\frac{1}{3}$ the width of the face and place them astride a corner of the block, as in Fig. 194, taking care to have the foot *b* just as far from the corner as the foot *a*, judging of the distance by the eye.

Place the metal foot of the dividers at *b*, and with the pencil-foot mark the point *c*, as in Fig. 195.

Then place the metal foot at *c*, and with the pencil-foot mark the point *d*, as in Fig. 196.

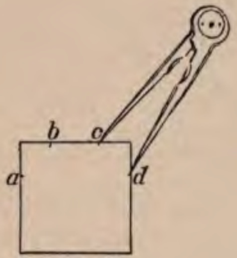


Fig. 196.

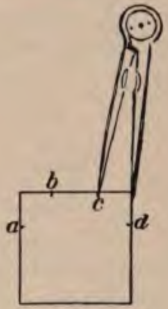


Fig. 197.

If *c* and *d* are judged equi-distant from the corner between them, then the points *a*, *b*, *c* and *d* locate the lines of the octagon. If *c* and *d* are not equi-distant from the corner between them, change the dividers and try again, until the spacing is correct. When the points *a*, *b*, *c* and *d* have been accurately placed, set the dividers as in Fig. 197, so as to enclose the space from any point to the adjacent corner. Take care not to change the dividers, and scribe as in Fig. 169.

LESSON LV.

TO MAKE A CYLINDER.

Make an octagonal prism, as in the previous lesson. Cut the block sixteen-sided a short distance from each end, as in Fig. 198. Hold the knife in cutting *a* so as to make equal angles with the faces *b* and *c*, as in Fig. 199.

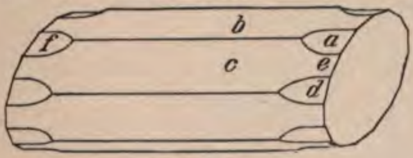


Fig. 198.

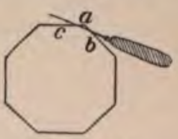


Fig. 199.

In doing this be sure that the new faces *a* and *d* are equal in width to the part of the old face *e* left between them. Having thus prepared both ends of the block, cut straight across from *a* to *f*, making the new face of uniform width. In the same way cut all corresponding places around the block, and the work will appear as in Fig. 200, having sixteen equal sides.

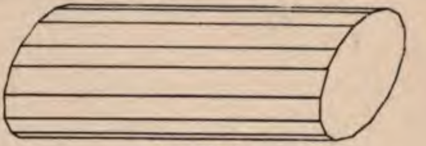


FIG. 200.

This entire process of making a sixteen-sided prism of an octagonal prism will have to be done by the eye, without the aid of lines, and will require care and skill. In the same way make the prism thirty-two sided and then round. Take $\frac{1}{8}$ of a sheet of No. 1 sandpaper, fold it over a block 3 in. x $\frac{7}{8}$ in. x $\frac{7}{8}$ in., and move it to and fro with the right hand, while the work is held against it and rolled with the left hand. Notice particularly high places and smooth them off.

Finally take a piece of No. $\frac{1}{2}$ sandpaper and hold it with the right hand around the cylinder, then roll or slide the cylinder with the left hand. Problem 55, Plate XIII, shows a perspective view of the cylinder.

LESSON LVI.

TO MAKE A SQUARE PYRAMID.

Take a block 1 $\frac{1}{2}$ in. x $\frac{7}{8}$ in. x $\frac{7}{8}$ in. Set the gauge a little less than half the thickness of the block, testing to see if correct by placing two points on the end, as in Fig. 201; these points should be about 1-32 in. apart. When the gauge

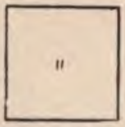


FIG. 201.

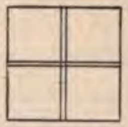


FIG. 202.

is adjusted, gauge four lines on one end of the block, as in Fig. 202.

Draw pencil lines on two opposite sides of the block, from the ends of the above lines to the corners of the opposite end, as in Fig. 203.

Cut straight across to these lines, recalling triple application of Rule IV, in Figs. 142 to 144. The work will appear wedge-shaped, as in Fig. 204.

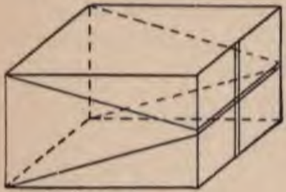


FIG. 203.

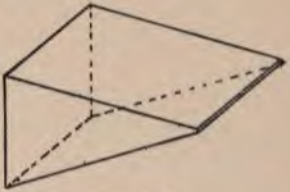


FIG. 204.

Notice the gauge marks on the middle of the thin edge of the wedge. Join these points to the corners of the opposite end of the block, as in Fig 205.

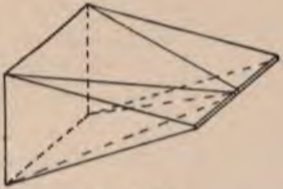


FIG. 205.

Cut away the wood outside of these lines, observing triple application of Rule IV. If desired, carefully sandpaper the sides that are cut. A perspective view of the square pyramid is shown in Problem 56, Plate XIII.

LESSON LVII.

TO MAKE AN OCTAGONAL PYRAMID.

Make a square pyramid, as in the previous lesson. Draw an octagon on the base. Draw lines on the sides from the corners of the octagon to the apex of the pyramid, as in Fig. 206.

Cut to these lines and finish the sides that have been cut by using sandpaper, if desired. Problem 57, Plate XIII, shows a perspective view of an octagonal pyramid.

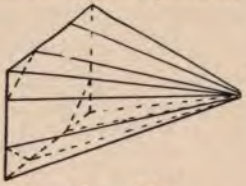


FIG. 206.

LESSON LVIII.

TO MAKE AN HEXAGONAL PYRAMID.

Take a block 1 ½ in. x 1 in. x ⅞ in. Set the gauge a little less than half of the ⅞ in. thickness and gauge two lines on one end, as was done with the square pyramid. Then set the gauge a little less than half of the 1 in. width and gauge two more lines, when the work will appear as in Fig. 207.

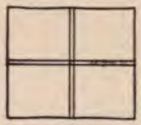


FIG. 207.

Make a pyramid of the block, as the square pyramid was made. This pyramid will have a rectangular base. Describe a hexagon on the base, as in Lesson LIII. The block will then appear as in Fig. 208.

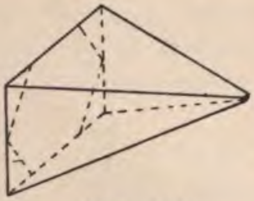


FIG. 208.

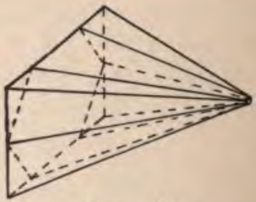


FIG. 209.

Draw lines from the corners of the hexagon to the apex of the pyramid, as in Fig. 209.

Cut to these lines, recalling triple application of Rule IV. Problem 58, Plate XIII, shows a perspective view of a hexagonal pyramid.

LESSON LIX.

TO MAKE A CONE.

Make an octagonal pyramid as in Lesson LVII. Make it sixteen-sided, then thirty-two sided and finally round. Problem 59, Plate XIII, shows a perspective view of a cone.

LESSON LX.

TO MAKE A DOUBLE CONE.

Take a block 1 ½ in. x ⅞ in. x ⅞ in. Square a line around the middle of it, as in Fig. 210.

Set the gauge one quarter of the thickness, and on this middle line gauge two points on two opposite sides of the block, as in Fig. 211.

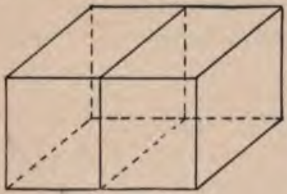


FIG. 210.

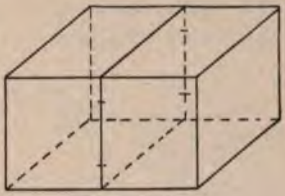


FIG. 211.

From these points draw lines to the corners of the sides, as in Fig. 212.

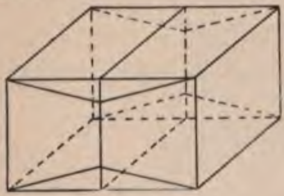


FIG. 212.

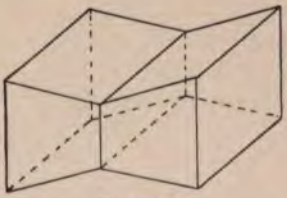


FIG. 213.

Cut straight across to these lines, and the work will appear as in Fig. 213.

With the same setting of the gauge, make points on the two faces just cut, draw lines from these points to the corners of the side as before, and cut to them. The work will then appear as in Fig. 214.

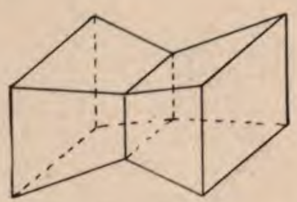


FIG. 214.

The block is now $\frac{7}{8}$ in. square at each end and 7-16 in. square in the middle. Draw an octagon on each end and on the 7-16 in. square in the middle, using the second or third method, Lesson LIV, for the middle. Connect the corners of the octagons by lines, as in Fig. 215.

Cut to these lines, and the work will appear as in Fig. 216, the block being octagonal in section throughout its length.

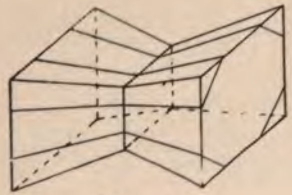


FIG. 215.

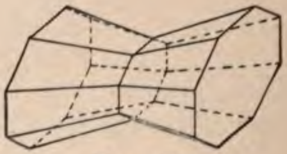


FIG. 216.

Next make it thirty-two sided, then round, as in Lesson LIX. A perspective view of a finished double cone is shown in Problem 60, Plate XIII.

LESSON LXI.

TO MAKE A SPOOL.

Take a block 1 $\frac{1}{2}$ in. x $\frac{7}{8}$ in. x $\frac{7}{8}$ in. Square around $\frac{1}{8}$ in. from each end, and with the gauge set one quarter of the thickness, gauge two lines on opposite sides, taking care that the gauged lines do not cross the squared lines, and the work will appear as in Fig. 217.

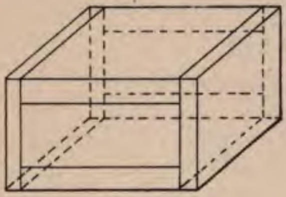


FIG. 217.

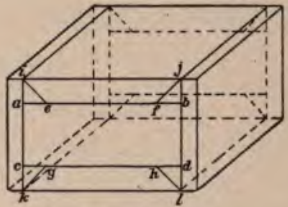


FIG. 218.

Measure from *a*, *b*, *c* and *d* 3-16 in. and place the points *e*, *f*, *g* and *h*; connect these points with *i*, *j*, *k* and *l*, as in Fig. 218. Lay out the opposite side of the block in the same way.

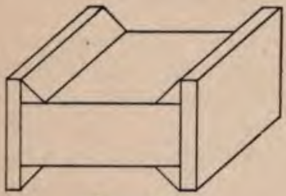


Fig. 219.

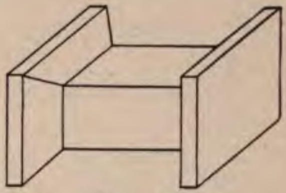


FIG. 220.

Cut straight across to these lines, and the block will appear as in Fig. 219.

Lay out and cut the other two sides in the same way, and the block will appear as in Fig. 220.

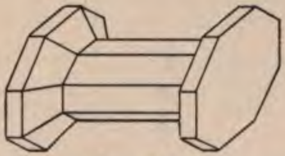


FIG. 221.

It is now a square spool. Place the necessary points and draw lines on the ends, beveled parts and middle, to make it octagonal, as in Lessons LIV and LVII. Cut to these lines, and the work will appear as in Fig. 221.

Make this octagonal spool into a sixteen-sided spool, then make it thirty-two sided and finish round. Problem 61, Plate XIII, shows a perspective view of a spool.

LESSON LXII.

TO MAKE A POINTER.

From a board ½ in. thick and 16 in. long, have strips machine-sawed which shall be ½ in. wide at one end and ¼ in. wide at the other, as in Fig. 222.

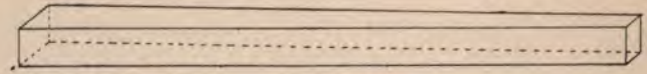


FIG. 222.

Draw the lines *a b* and *c d*, as in Fig. 223.

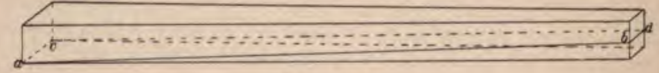


FIG. 223.

Cut to these lines, making a stick which tapers from ½ in. square on the end *a c* to ¼ in. square on the end *b d*. Cut the stick octagonal a short distance from each end, as in Fig. 224.

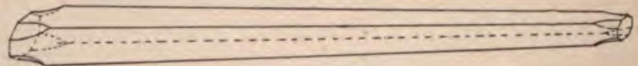


FIG. 224.

Cut the entire length octagonal, as in Fig. 225. This work will have to be done by the eye, and will test the pupil's skill.

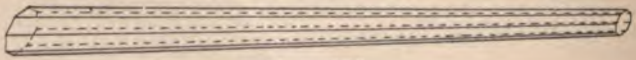


FIG. 225.

In the same way make the stick sixteen-sided and then round. Problem 62, Plate XIII, shows a perspective view of a pointer.

LESSON LXIII.

TO MAKE A SPHERE.

Take a 1 $\frac{3}{4}$ in. cube and find the center of each end by drawing diagonals, as in Fig. 226. Mark these centers *a* and *b*.

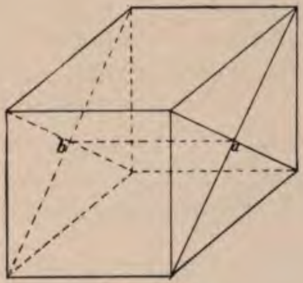


Fig. 226.

An imaginary line through the block, joining these points, will be the axis of a completed sphere.

To make an octagonal block of the 1 $\frac{3}{4}$ in. cube set the gauge $\frac{1}{2}$ in. and gauge four lines on each end and two on each side of the cube, as in Fig. 227.

Cut to these lines and the work will appear as in Fig. 228.

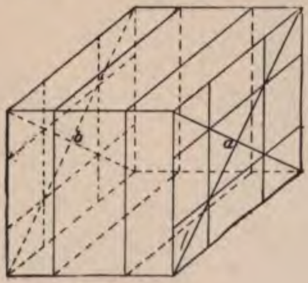


Fig. 227.

Set the dividers a little more than $\frac{1}{3}$ the width of an octagonal face, adjusting them as Figs. 194 to 196, and draw two lines on each side and four on each end, as in Fig. 229.

Cut to these lines, and the work will appear as in Fig. 230.

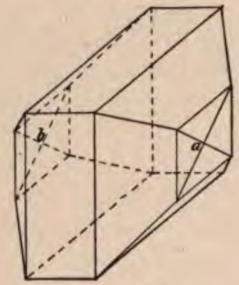


Fig. 228.

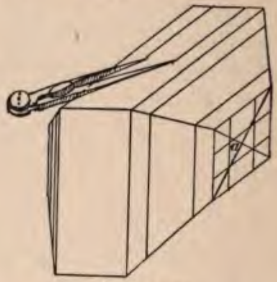


Fig. 229.

In a similar way make the block thirty-two sided, when the side view will be nearly round and the end view will remain square.

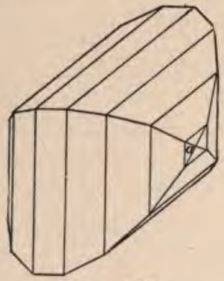


Fig. 230.

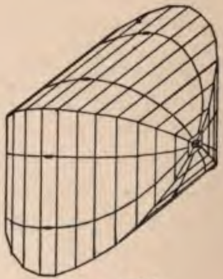


Fig. 231.

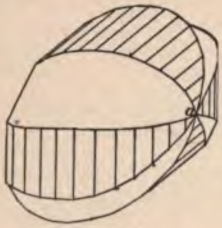


Fig. 232.

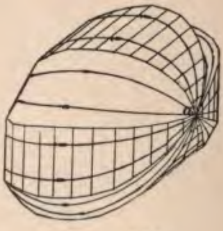


Fig. 233.

Set the gauge ½ in., gauge two points on the widest part of each face and draw lines from *a* to *b* through these points, as in Fig. 231.

Cut to these lines, and the work will appear as in Fig. 232.

Set the dividers a little more than $\frac{1}{3}$ the width of a face in its widest place, adjusting them as directed in Lesson LIV; place two points on each face at its widest place, and draw lines from *a* to *b*, through these points, as in Fig. 233.

Cut to these lines and the work will be sixteen-sided. In the same way make the block thirty-two sided. Then make it round, by cutting away high places, using sandpaper if desired, as in previous lessons. A perspective view of a sphere is shown in Problem 63, Plate XIV.

LESSON LXIV.

TO MAKE AN ELLIPSOID.

Take a block 2 $\frac{5}{8}$ in. long, x 1 $\frac{3}{4}$ in. square. Draw lines lengthwise along the middle of two opposite sides, and also along the middle of the ends. Square a line around the middle of the sides. Mark the central points of the ends *a* and *b*.

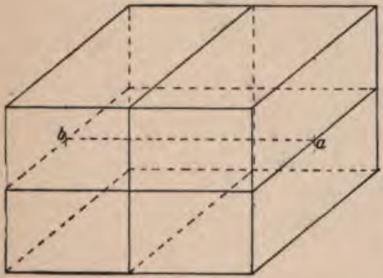


FIG. 234.

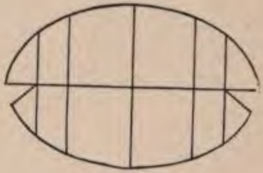


FIG. 235.

An imaginary line connecting these points will be the axis of the completed ellipsoid, and the block will appear as in Fig. 234.

Draw an ellipse on cardboard as in Lesson XL, having the long diameter 2 $\frac{5}{8}$ in. and the short diameter 1 $\frac{3}{4}$ in. Divide each half of the long diameter into two equal parts, and also the end divisions into two equal parts. Through each of these points draw lines perpendicular to the long diameter. Cut the ellipse from the cardboard and cut notches on each end of the long diameter, making an elliptical templet, as in Fig. 235.

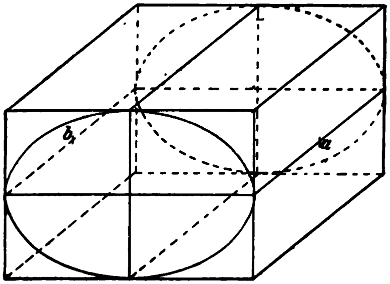


Fig. 236.

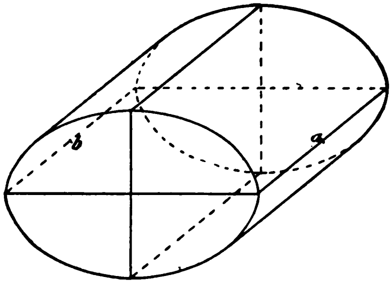


Fig. 237.

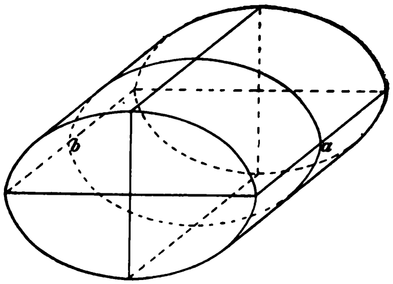


Fig. 238.

Using this templet, draw ellipses on the two opposite sides of the block that have the lengthwise lines drawn on them, having the diameter of the templet correspond with these lines, as in Fig. 236.

Cut straight across from one ellipse to the other, and the work will appear as in Fig. 237.

With dividers set at half the thickness of the block, scribe a line around it, as in Fig. 238.

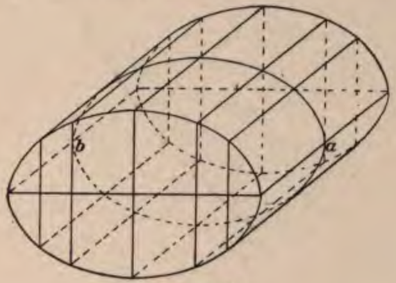


Fig. 239.

Place the elliptical templet on the elliptical sides of the block, and place points on the curved edges against the ends of the perpendicular lines. Join these points by straight lines drawn around the block, as in Fig. 239.

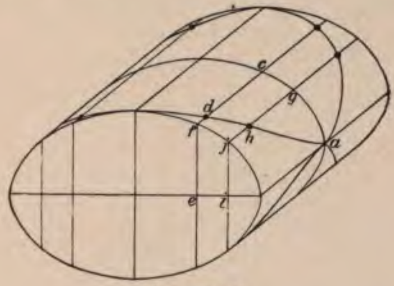


Fig. 240.

Place points making the distance *c d* equal to *e f*, and *g h* equal to *i j*. Mark corresponding lines on the block in the same way. Draw curved lines from *a* to *b* through these points, as in Fig. 240.

Cut to these curves, and the block will appear as in Fig. 241. An end view will be square and a side view elliptical.

Set the gauge $\frac{1}{2}$ in. and make two points on each face at its widest place. Draw lines from *a* to *b* through these points, as in Fig. 242.

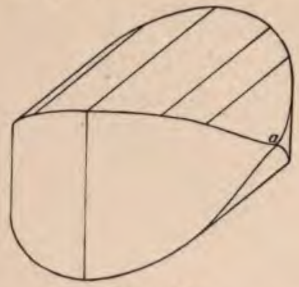


Fig. 241.

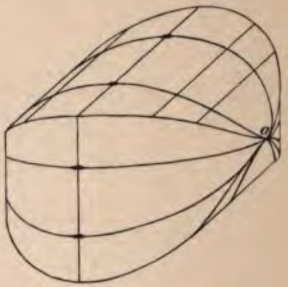


Fig. 242.

Cut to these lines and an end view will be octagonal. Make the block sixteen-sided and then thirty-two sided, following directions given for a sphere. Finish by using sandpaper as in previous lesson, unless it is desirable to show how perfectly the block can be finished with the knife. Problem 64, Plate XIV, shows a perspective view of an ellipsoid.

LESSON LXV.

TO MAKE AN OVOID.

Take a prepared block $2\frac{5}{8}$ in. long x $1\frac{3}{4}$ in. square. Draw

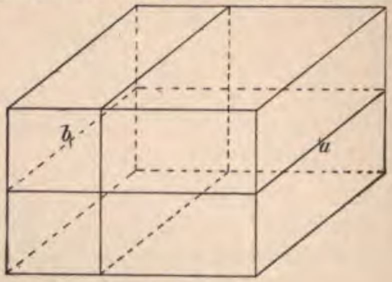


Fig. 243.

lines lengthwise along the middle of two opposite sides, and of the ends. Square a line around the block 1 in. from the left end. Mark the centers of the ends *a* and *b*, as in Fig. 243.

Draw an oval on cardboard, with the long diameter 2 $\frac{5}{8}$ in. and the short diameter 1 $\frac{3}{4}$ in. The short diameter crosses the long diameter 1 in. from the left end. Divide each part of the long diameter in two equal parts, and the end divisions in two equal parts. Through these points draw lines perpendicular to the long diameter. Cut the oval from the cardboard, and cut notches at the ends of long diameter, as in Fig. 244.

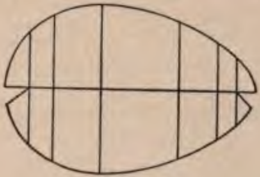


FIG. 244.

Use this templet as the elliptical templet was used, follow the directions given for the ellipsoid, and finish the ovoid. Problem 65, Plate XIV, shows a perspective view of an ovoid.

LESSON LXVI.

TO MAKE A VASE.

Take a prepared block 2 $\frac{5}{8}$ in. x 1 $\frac{3}{4}$ in. square. On cardboard draw a vase 2 $\frac{5}{8}$ in. long x 1 $\frac{3}{4}$ in. wide, with its top and base 1 $\frac{1}{8}$ in. See Lesson XV, for method of drawing a vase.

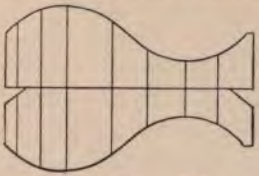


FIG. 245.

Draw lines parallel with the base at the widest and narrowest places. Also $\frac{1}{8}$ in., $\frac{3}{8}$ in., 1 $\frac{1}{8}$ in., 1 $\frac{1}{2}$ in. and 2 $\frac{1}{4}$ in. from the base. Cut this drawing from the cardboard and cut notches at the middle of the top and base, making a vase templet, as in Fig. 245.

Draw lines lengthwise along the middle of two opposite sides of the block. Using the templet, draw vases on these two sides. Set the gauge to the distance *a b*, and gauge two lines on each end, and the block will appear as in Fig. 246.

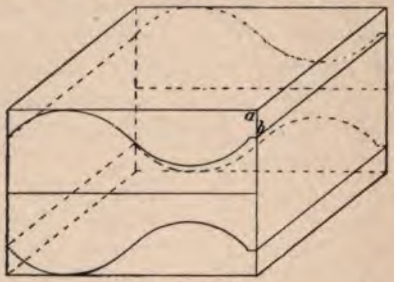


FIG. 246.

Cut straight across to the lines of the vases, and the work will appear as in Fig. 247.

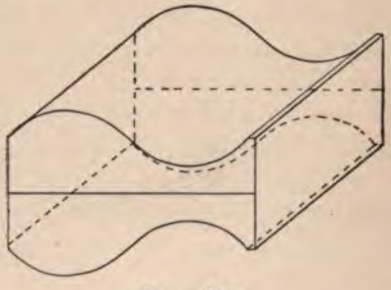


FIG. 247.

Scribe lines lengthwise along the middle of the curved faces, and with gauge set as before, gauge two lines on each end. Apply the templet to the flat sides of the block, place points on the curved faces at the ends of perpendicular lines, join these points by straight lines drawn around the block, and the work will appear as in Fig. 248.

Place points on these lines, making the distance *a b* equal to *c d* and *e j* equal to *g h*. Mark remaining lines in a corresponding way, and draw curves through these points, as in Fig. 249.

Cut to these lines, and the block will be a square vase, as in Fig. 250.

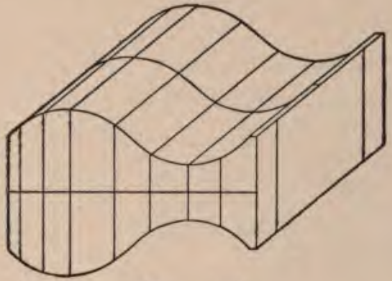


FIG. 248.

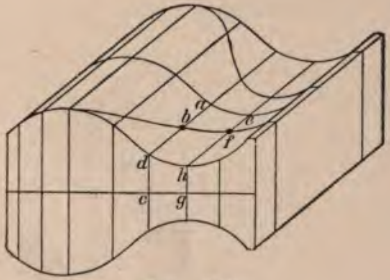


FIG. 249.

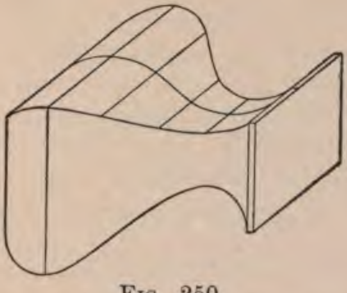


FIG. 250.

Follow directions given for the ellipsoid and make the block octagonal, sixteen-sided, thirty-two sided, and finish round. Problem 66, Plate XIV, shows a perspective view of a vase.

LESSON LXVII.

TO MAKE A CONOID.

Take a block 2 5/8 in. x 1 3/4 in. square. On one end gauge four lines, as in Fig. 202. On a piece of cardboard 9 in. x 3 in. draw a straight line lengthwise 1/4 in. from one edge, and through the center draw a line perpendicular to it. On the longer line place points 7/8 in. and 3 1/2 in. each way from the center, mark these points *a* and *b*, *c* and *d*. Set the dividers 4 3/8 in. With *c* as a center describe the arc *a e*, and with *d* as a center describe the arc *b e*.

Draw two lines parallel to the line *a b*, 1 in. and 2 in. respectively from it, and between it and *e*, as in Fig. 251. Cut out to the lines *a b e*, making a conoid templet.

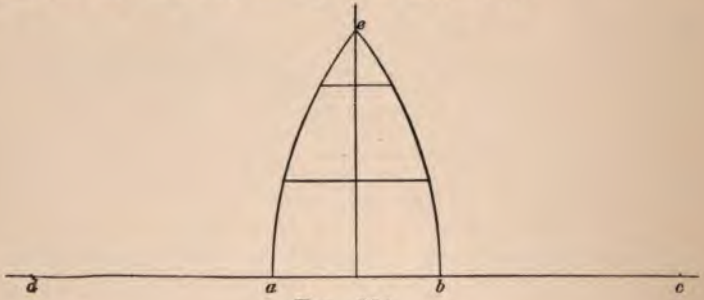


FIG. 251.

Using this templet draw conoids on two opposite sides of the block, and following directions given for the cone and ellipsoid, make the block square, then octagonal, sixteen-sided and thirty-two sided, and finish round. Problem 67, Plate XIV, show a perspective view of a conoid.

LESSON LXVIII.

TO MAKE A RING SQUARE IN SECTION.

Take a board 2 5/8 in. square x 1/2 in. thick. Make it a 2 1/2 in. circular board, as in Lesson XXXIX. Following directions given in Lesson XLV cut a circular hole 1 1/2 in. in diameter, making a ring 1/2 in. square in section.

Let pupils who are sufficiently advanced study out the problem how to make a ring the thickness of the wood square, in section. Problem 68, Plate XIV, shows a perspective view of a ring square in section.

LESSON LXIX.

TO MAKE A RING OCTAGONAL IN SECTION.

Make a ring square in section, as in last lesson. Before cutting the opening describe two circles where the corners of the octagon are to be, finding the location of these corners as directed in Lesson LIV, second or third method, and the block will appear as in Fig. 252.

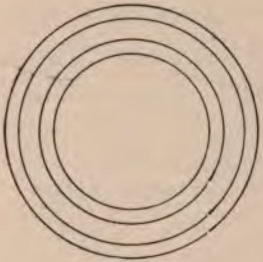


FIG. 252.

Cut to the inner circle. Set the gauge as directed in Lesson LIV, and gauge two lines on the outer and two lines on the inner edge of the work, as in Fig. 253.

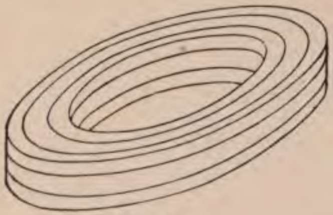


FIG. 253.

Cut to these gauged lines and to the circles, so as to make the ring octagonal in section. If it is desirable to make such a ring from a completed ring square in section, fit in a piece of ½ in. square stock, on which to place the center, as in Fig. 254.

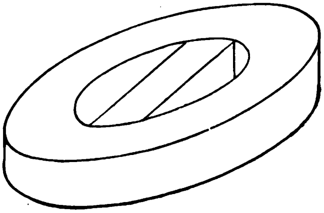


FIG. 254.

A perspective view of a ring octagonal in section is shown in Problem 69, Plate XIV.

LESSON LXX.

TO MAKE A RING ROUND IN SECTION.

Make a ring octagonal in section, as in the previous lesson, then make it sixteen-sided and finish round, following directions previously given. Problem 70, Plate XIV, shows a perspective view of a ring round in section.

THIRD YEAR.

SEVENTH GRADE.

PART II—JOINTS.

LESSON LXXI.

THE HALVED JOINT.

Problems to be executed in this part can be found in perspective on Plates XV and XVI. In beginning Lesson LXXI take a strip of wood ½ in. square and cut off two pieces 3 in. long. Cut the first end of each as described in Lesson L, and the second end as in Lesson LI. Square across one side ¼ in. from the center and halfway across the adjacent sides, and the work will appear as in Fig. 255.

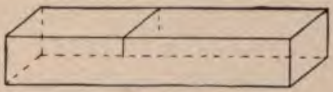


Fig. 255.

Lay the second piece on the first, so that the edge *a b* shall correspond with the line just drawn. With the knife make a point on the first stick against the side of the upper stick, as in Fig. 256.

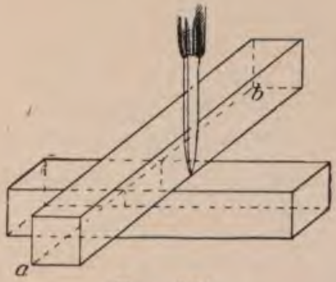


Fig. 256.

Through this point square lines as before, and the first stick will appear as in Fig. 257.

Set the gauge half the thickness of the stock, testing its accuracy by gauging two points from opposite edges, as in Fig. 258. When the two points are in line as at *c* the gauge is correctly set.

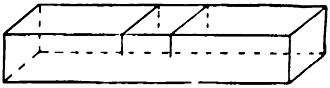


Fig. 257.

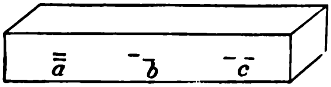


Fig. 258.

Gauge lines joining the ends of the squared lines. Cut out the portion of wood enclosed between these lines, following instructions given in previous lessons, and the work will appear as in Fig. 259.

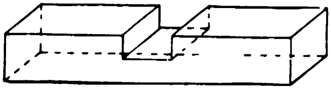


Fig. 259.

Lay out and cut the second piece in the same way, and the two sticks will fit together and form a halved joint. Problem 71, Plate XV, shows a perspective view of a halved joint.

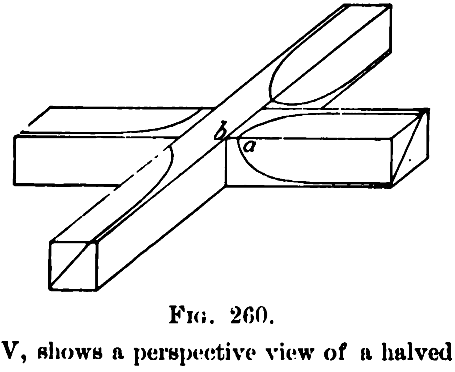


Fig. 260.

LESSON LXXII.

THE WINDMILL.

Cut from $\frac{1}{2}$ in. square stock two pieces 4 in. long and halve them together, as in the previous lesson. Draw lines enclosing the upper left-hand corner of each arm, as in Fig. 260. It will be just as well to enclose the upper right-hand corner, only the same corner of every arm must be enclosed. The point *a* is $\frac{1}{8}$ in. from the point *b*.

Cut to these lines, turn the work over and cut the opposite corners in the same way. Find the center of the halved joint on one side, and take a brad awl, large enough to make a hole in which a 1 $\frac{1}{4}$ in. No. 16, steel-wire nail will move freely. Hold the mill with an arm pointing up, push the awl in a little way and twist it back and forth a few times, as in Fig. 261.

Turn the mill so as to bring a second arm pointing up, push the awl in a little farther and twist as before; bring the third and fourth arms in the same position, and do as before, pushing the awl in a little farther each time, until it is halfway through the joint. Center the joint on the opposite side and repeat the directions given above, until the awl comes through the hole first made. The object of doing this is to make a perpendicular hole.

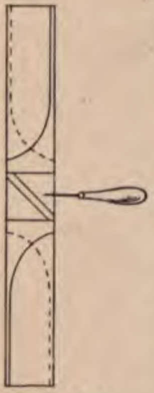


FIG. 261.

To make the handle cut off a piece of the $\frac{1}{2}$ in. square stock 6 in. long. Center one end, and with an awl smaller than the nail make a hole, as in Fig. 262.

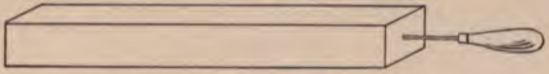


FIG. 262.

Work the awl as directed above, turning the stick so as to bring each side up successively, and make the hole as deep as the awl will allow.

Take a 1 ¼ in. No. 16, steel-wire nail, pass it through the hole made in the mill, and drive it into the hole in the end of the handle. Problem 72, Plate XV, shows a perspective view of a windmill and handle.

LESSON LXXIII.

THE HALVED FRAME.

Cut off two pieces of ½ in. square stock 5 ¾ in. long, and two pieces 4 ⅛ in. long. Following directions given in Lesson LXXI halve them together, making the corner ½ in. from the ends, as at *a*, Fig. 263. Number each joint on both of its component pieces, in order that the frame may be correctly put together, if taken apart for any purpose, as at 1 1, 2 2, 3 3 and 4 4, Fig. 263. Call the side of the frame so marked the back side.

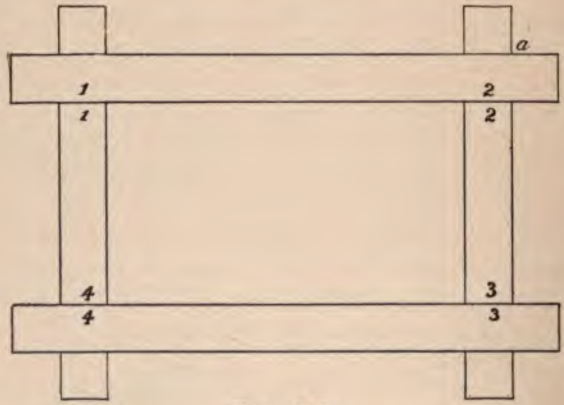


FIG. 263.

Scribe ⅛ in. on both sides of the frame and on the outer and inner edges, except the inner edges of the back side, stopping the scribed lines about ¼ in. from the corner joints, as in Fig 264.

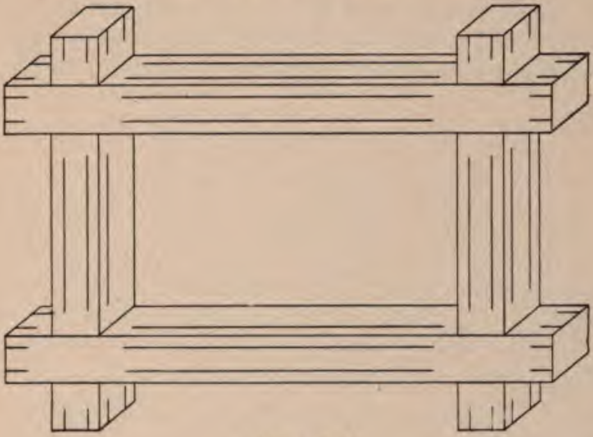


FIG. 264.

Chamfer to these lines and round the end of the chamfer, beginning ⅛ in. from each of the four joints, as in Fig. 265.

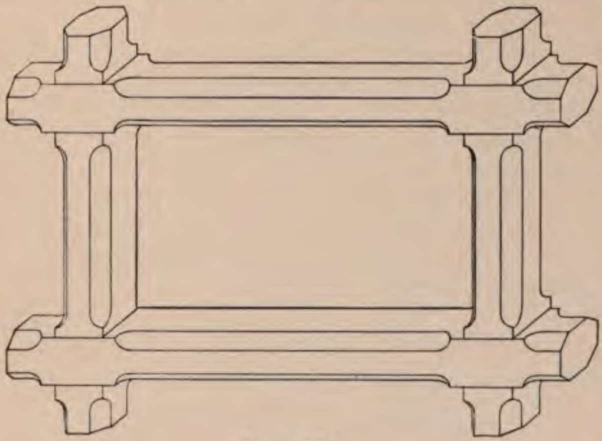


FIG. 265.

Lay out a rabbit 3-16 in. wide and deep on the inner edges of the back side of the frame. This laying out may be done by scribing with dividers, or the frame may be taken apart and the lines gauged. Remove the wood between these lines, making a rabbit as in Lesson XLVII. Fig. 266 is a section of the molding in Fig. 265, after the rabbit is cut.

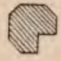


FIG. 266.

The frame is now complete and is the right size to receive a card photograph. It will please the pupils to be allowed to sandpaper these frames and cover them with two coats of shellac. The first coat should dry a few hours, then sandpaper the frame again to remove all roughness, taking care not to sandpaper through the shellac. Special care will be needed to protect the corners. The best way to sandpaper the chamfered faces is to fold a small piece of sandpaper over a ½ in. square stick. After sandpapering, put on the second coat of shellac. Problem 73, Plate XV, shows a perspective view of this frame.

LESSON LXXIV.

THE MITER JOINT.

First make a miter bevel. Take a piece of ⅜ in. wood about 2 ½ in. long by ⅞ in. wide. The edges of the board must be true, and parallel with each other. Square lines around near each end. Place points ⅞ in. from the squared lines on one edge, and square across the edge. Draw oblique lines from these lines to the point where the squared lines meet the opposite edge of the board, as in Fig. 267.

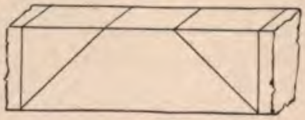


FIG. 267.

Cut to these lines and the ends will make an angle of 45° with the long edge. On one side of the board gauge a line ¼ in. from the long edge, from the ends of this line square lines halfway across the ends of the board. Set the gauge 3-16 in. and gauge a line on the short edge, and on the ends to meet the squared line. Set the gauge ¼ in. and then 7-16 in. and gauge lines from the short edge, and the work will appear as in Fig. 268.

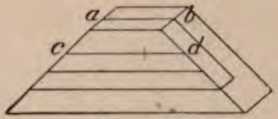


FIG. 268.

Draw the knife through the lines *a b* and *c d* alternately, until the wood enclosed between them is removed; in the same way remove the remaining sections, and the work will appear as in Fig. 269.

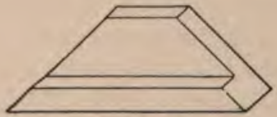


FIG. 269.

Make the miter joint as follows: From ½ in. square stock cut off two pieces 3 in. long. Lay the miter bevel on one of them, the shoulder of the bevel being close to the side of the stick and its end just meeting the end of the stick, as at *e*, in Fig. 270.

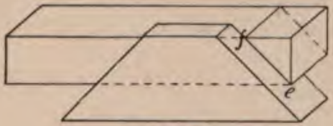


FIG. 270.

Draw a line on the stick along the end of the bevel, square

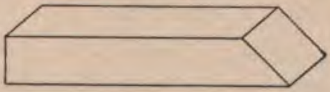


FIG. 271.

across the adjacent side of the stick at *f*, and use the miter bevel to mark the third side. Cut to these lines, observing Rules III and IV, and the work will appear as in Fig. 271.

Make one end of the other stick in the same way. Then take a true board of sufficient size, lay a piece of paper on it to keep the joints from sticking to the board. Glue the mitered ends of the sticks, lay them on the paper, press them firmly together, and let them remain until dry. Problem 74, Plate XVI, shows a perspective view of a miter joint. If extra work is needed at this point pupils may make a mitered picture frame.

LESSON LXXV.

THE MORTISE AND TENON JOINT.

Take two sticks 3 in. x 1 in. x $\frac{1}{2}$ in. Make a mortise at the center of one of them as follows: On one side of the stick place a point $\frac{1}{4}$ in. from the center, and through it with try-square and knife make a line $\frac{1}{2}$ in. long, the center of the line corresponding with the above point. Place the edge of the second stick on the side of the first, as in Fig. 256, make a point and square a line $\frac{1}{2}$ in. long through it. As in Fig. 160, make corresponding lines on the opposite side. Set the gauge $\frac{1}{4}$ in. and gauge lines joining the ends of the squared lines, making $\frac{1}{2}$ in. squares on the opposite sides of the stick. Cut to these lines as in Lesson XLIV. Be sure to make the hole, in the center of the stick as large, or even a little larger than the outside edges, and the work will appear as in Fig. 272.

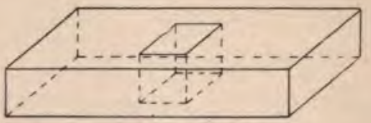


FIG. 272.

A hole which is made to receive a tenon is called a mortise.

On the second stick square around $\frac{1}{2}$ in. from one end, using knife and try-square. With gauge set as above, gauge two lines on the end, parallel with the edges, and on each side from the end to the squared line. Cut to these lines, and the work will appear as in Fig. 273.

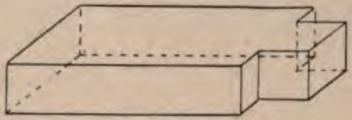


Fig. 273.

An end so cut is called a tenon, and should just fit the mortise. Problem 75, Plate XVI, shows a perspective view of a mortise and tenon joint.

LESSON LXXVI.

THE LOCKED JOINT.

Take two boards 3 in. x 2 ¼ in. x ⅜ in. and draw a line around each board, as far from one end as the thickness of the stock. This can be done by the gauge, and is one of the rare cases where the gauge is used crosswise of the grain, or it can be done with the square and finely-pointed pencil. Place points along the end at every ⅜ in. and from these points square across the end and on each side to the gauged lines. Be sure that this is done accurately and carefully. The work will appear as in Fig. 274.

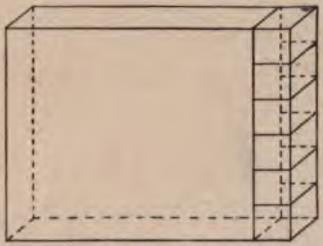


Fig. 274.

With the knife and try-square mark deeply on both sides of the board the portions of the gauged line which are heavily drawn in Fig. 275.

Remove the portion A, as the tenon was cut in the previous lesson, and the portions B and C in a similar way to the mortise. Do not cut quite to the middle of the pencil lines. The work will appear as in Fig. 276.

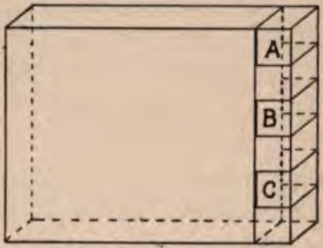


Fig. 275.

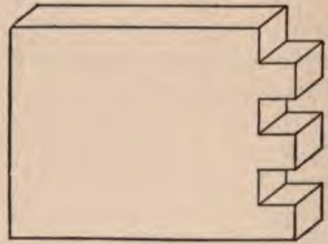


Fig. 276.

Make the second board in the same way, and the two boards will fit or lock together, making a corner joint which is much used and is known as a locked joint. Pupils who work rapidly may cut the opposite ends of the boards in the same way. Problem 76, Plate XVI, shows a perspective view of a locked joint.

LESSON LXXVII.

THE DOVETAILED JOINT.

First make a dovetailed bevel as the miter bevel was made. It is like that bevel in all respects except the angles at the ends.

The measure $\frac{7}{8}$ in. on the upper edge, in Fig. 267, in this case must be $\frac{1}{8}$ in., as in Fig. 277.

Complete the dovetailed bevel, following directions given for the miter bevel, and the work will appear as in Fig. 278.

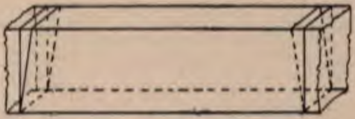


FIG. 277.

Take two pieces of ⅜ in. stock, 3 in. x 2 ¼ in. Set the gauge to the thickness of the board, as in previous lesson, and gauge very lightly from one end on both sides of one board. Square across each edge from the ends of these lines. Place points on the end of the board 3-16 in. from each edge, and every ⅜ in. between them, and square across the end at every one of these six points. Be sure this work is done accurately and carefully, and the work will appear as in Fig. 279.

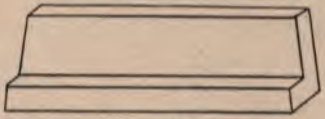


FIG. 278.

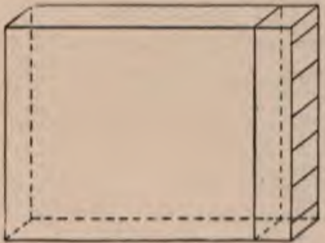


FIG. 279.

Use the dovetailed bevel as the miter bevel was used, and draw oblique lines on both sides of the board, from the ends of the squared lines to the gauged line, as in Fig. 280.

With knife and try-square mark deeply on both sides of the board the portions of the gauged lines which are heavily drawn, and mark an *x* on each portion to be cut out, as in Fig. 281.

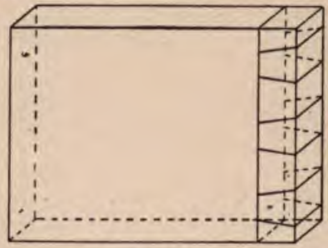


FIG. 280.

Cut out the parts of the board marked *x* following directions given for making locked joint, and the work will appear as in Fig. 282.

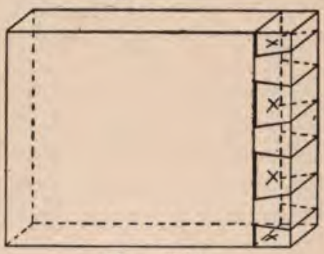


FIG. 281.

The projections are called dovetailed tenons. Take the second board, gauge it and place points on one end like the

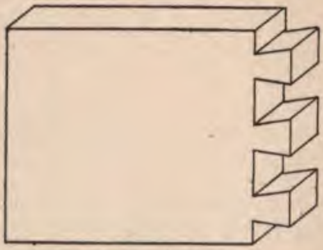


FIG. 282.

first. From each of these six points square lines on one side of the board, from the end to the gauged line, and on the end draw oblique lines meeting these squared lines, using the dovetailed bevel, and the work will appear as in Fig 283.

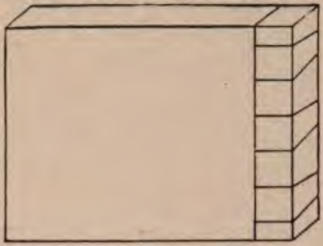


FIG. 283.

From the ends of these oblique lines square on the other side of the board to the gauged line on that side, and the work will appear as in Fig. 284.

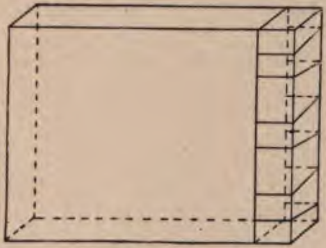


FIG. 284.

With knife and try-square mark deeply on both sides of the

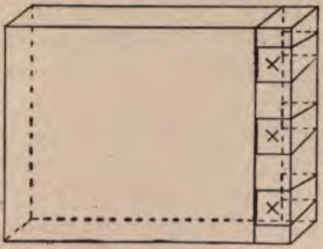


FIG. 285.

board the portions of the gauged lines which are heavily drawn and mark with an x the parts of the board to be cut out, as in Fig. 285.

Cut out the parts marked x following directions given for the locked joint, and the work will appear as in Fig. 286.

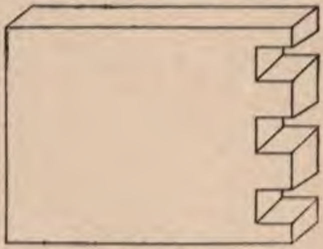


FIG. 286.

When both boards are completed, they should fit together closely and make a dovetailed corner joint. Problem 77, Plate XVI, shows a perspective view of a dovetailed corner joint.

LESSON LXXVIII.

THE BOX.

To hold the work of the year make a mitered-corner box 9 in. long x 5 in. wide x 3 $\frac{7}{8}$ in. deep, outside measure. Take two boards machine-sawed 9 in. x 3 $\frac{3}{4}$ in. x $\frac{3}{8}$ in. for the sides of the box, and two boards 5 in. x 3 $\frac{3}{4}$ in. x $\frac{3}{8}$ in. for the ends. Set the gauge to the thickness of the stock ($\frac{3}{8}$ in.) and from each end gauge a line on one side of each board. If the board is warped at all gauge these lines on the hollow or concave side, for reasons which will appear when the joints are nailed. Complete the laying out, and cut each end of each board following the directions given for the miter joint. The ends of boards so cut are said to be mitered, or cut to a miter bevel. Set the gauge $\frac{1}{8}$ in. and gauge on the short side of each board from one edge. Set the gauge 3-16 in. and gauge from the side on the adjacent edge, and cut a rabbit. Each board will appear as in Fig. 287. The dimensions in this figure are of an end board.

Lay one of the side pieces on two small strips. Drive four ¾ in. No. 18 steel-wire brads along the middle of each mitered

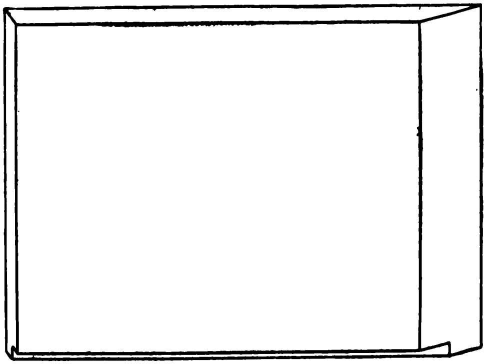


Fig. 287.

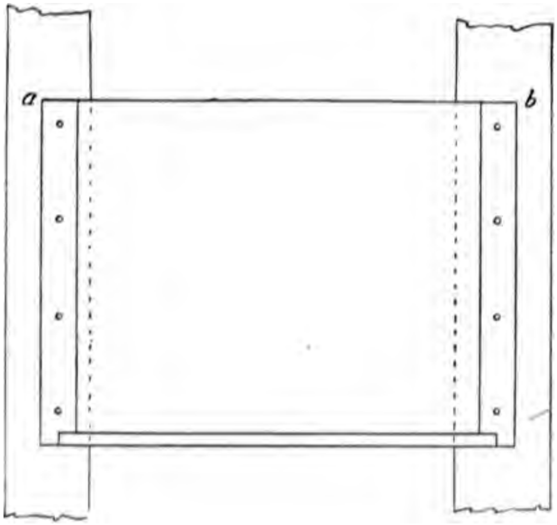


Fig. 288.

end, the first brad should be ¼ in. from the edge *a b*, and the others 1 in. apart. Treat the other side-piece in the same way, and each will appear as in Figs. 288 and 289, the former being a top view and the latter an edge view.

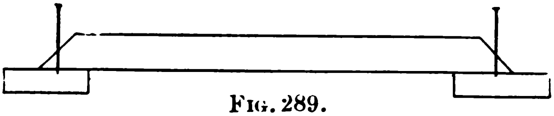


FIG. 289.

Draw out the brads and insert them from the opposite side of the board. The object in driving them as above has been to make holes in the proper places. Prepare the ends in the same way, except to start the first brad $\frac{3}{8}$ in. from the edge *a b*.

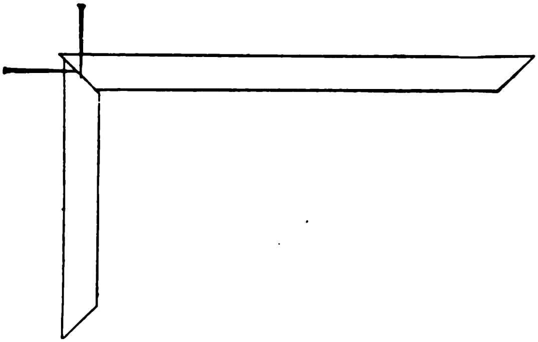


FIG. 290.

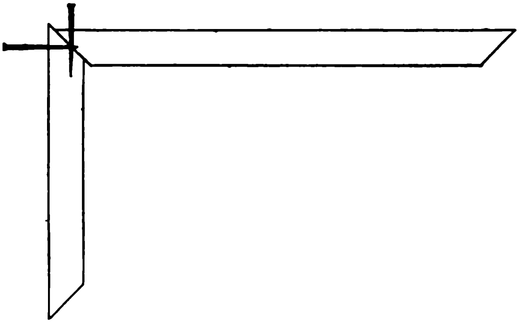


FIG. 291.

Let one pupil assist in holding an end-piece erect on the desk cover, with a side-piece on it and projecting nearly 1-16 in. beyond it, as in Fig. 290, while another pupil drives the line of brads, first driving the two extreme brads in the row. Drive each brad about one half of its length. This will bring the side-piece down so that its end will meet and pass the end of the end-piece, as in Fig. 291.

Turn the work so that the side-piece is erect and drive the four brads in the end-piece half their length, bringing the corners exactly together, as in Fig. 292.

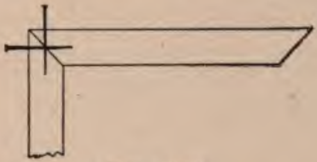


FIG. 292.

Inspect the joint and drive as judgment dictates, until the eight brads are driven home and the joint is complete. Take the other side-piece and end-piece and nail them in the same way and the halves of the frame will be duplicates. Nail the remaining joints in the same way and the frame is complete.

Take ⅛ in. stock and cut out a board 8 ⅝ in. x 4 ⅝ in. Nail it in the rabbit of the frame for the bottom of the box. Take ⅛ in. stock and make a cover as directed in Lesson XXIII. If desired the corners of this box may be lock-jointed instead of mitered, remembering to make the rabbit for the bottom. The best way to fasten locked-joints is to glue them, though they may be nailed. If glued the work must be held firmly together while the glue is drying. Take stout twine, place a waste block on each side to protect the corners of the frame, and wind the twine around half a dozen times or more near one end and tie securely. Bind the strands which cross the upper side of the frame with those which cross the lower side, and the work will appear as in Fig. 293.

Wind twine around near the other end and bind as before, also wind twine around the ends near the middle and bind in the same way. Before setting the frame away to dry, test it with the try-square and wrench it into position if necessary.

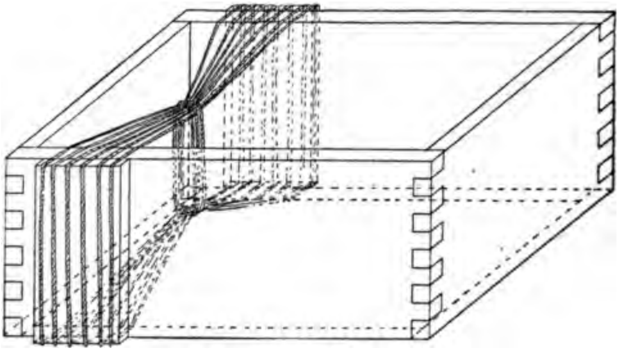


FIG. 293.

After drying three hours or more remove the twine, sandpaper off any portions of the tenons which project and complete the frame as the mitered box. Problem 78, Plate XVI, shows a perspective view of a mitered box. A, is a section of the frame and bottom.

FOURTH YEAR.

EIGHTH GRADE.

MECHANICAL
AND NATURAL FORMS.

LESSON LXXIX.

UNIFORM WIDTHS AND LENGTHS.

Take a piece ⅛ in. stock 4 ½ in. long, rough measure. Make several pieces exactly 1 in. wide and 4 in. long. Some of the rapid workmen may make ten or twelve pieces, while the slowest may not make more than two, but every piece should be of correct dimensions, and the quality of the work and not the quantity must be the test. Four pieces laid together with their sides touching as in Fig. 294 should present a smooth surface along the edges and ends.

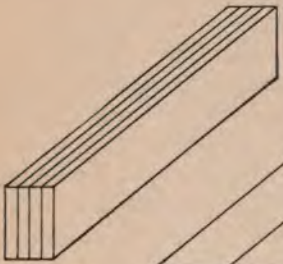


Fig. 294.

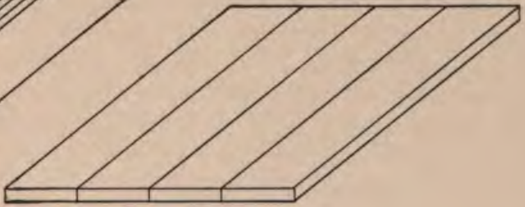


Fig. 295.

Lay them together with their edges touching as in Fig. 295, and they should cover exactly four inches.

If laid with ends touching they should cover exactly sixteen inches. This may be considered a test lesson. Pupils who perform the work satisfactorily may be expected to succeed, and those who do not will probably not be able to take up this year's work.

LESSON LXXX.

THE SAW MODELS.

Take $\frac{1}{8}$ in. stock and finish a piece 7 $\frac{1}{2}$ in. long and 2 in. wide, and from it make two pieces, each $\frac{3}{4}$ in. wide at one end and 1 $\frac{1}{4}$ in. at the other, as in Fig. 296.

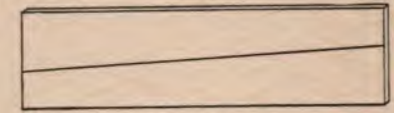


FIG. 296.

On the straight edge of one piece point off every $\frac{3}{8}$ in. and gauge a line 3-16 in. from that edge on both sides of the board, as in Fig. 297.

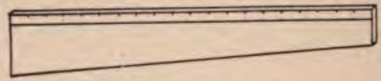


FIG. 297.

At every point cut down to the gauge line vertically and from the next right-hand point cut obliquely to the place cut down, observing directions given in connection with Fig. 66. A, Problem 80, Plate XVII. shows a model of a slitting saw.

Take the second piece, point off every $\frac{1}{4}$ in. on the straight edge, gauge a line 3-16 in. from that edge on both sides of the board, and cut obliquely both ways from every point down to the gauged line, as in Fig. 298.

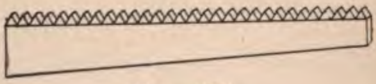


FIG. 298.

Hold the board with the side toward you. Bevel both edges of the first tooth on the side toward you and both edges of the second tooth on the side from you, and in this way alternately cut all of the teeth. B, Problem 80, Plate XVII, shows a model of a cutting-off saw.

LESSON LXXXI.

THE PINION AND GEAR MODEL.

Take a piece of ⅛ in. stock about 1 ½ in. square. Center it and describe three circles ¾ in., 1 in. and 1 ¼ in. diameter respectively. Divide the inch circle into eight equal parts and the work will appear as in Fig. 299.

Set the dividers so as to cover one of these parts, place the foot on each division point successively and describe arcs terminating on the outer and inner circles as in Fig. 300.

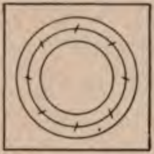


FIG. 299.

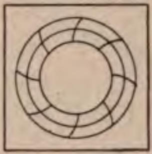


FIG. 300.

Divide each of these parts into two slightly unequal divisions so that the wider and narrower divisions shall alternate; the narrower division being on the concave side of the arc, as in Fig. 301.

Describe similar arcs through these points as in Fig. 302.

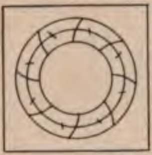


FIG. 301.

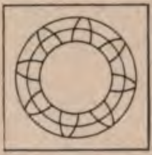


FIG. 302.

Cut the corners of the board away to the outer circle and then cut out the wider of the above spaces completing the pinion. A, Problem 81, Plate XVII, shows a pinion.

Pupils who have finished a pinion may make the gear. Take a piece of ⅛ in. board about 3 ½ in. square, center it, describe three circles 2 ¾ in., 3 in. and 3 ¼ in. diameter respectively, and divide the 3 in. circle in 24 equal parts. Set the dividers so as to cover one and one half of these parts, place the foot in proper position on the 3 in. circle and describe arcs successively through the points of division terminating on the inner and outer circles. Divide each of the parts in two slightly unequal divisions, as in the pinion, and describe arcs through them. Complete the gear by cutting as above. B, Problem 81, Plate XVII, shows a gear.

Take a piece of ½ in. square stock 1 in. long, make a handle, and fasten it to the gear near the teeth by driving a ¾ in. steel-wire nail through it, into the end of the handle. Secure the finished pinion and gear to a board 4 ½ in. x 3 ½ in. x ½ in. by driving ½ in. steel-wire nails through their centers into the board, placing them so the teeth shall play into each other freely. Problem 81, Plate XVII, shows a pinion and a gear.

LESSON LXXXII.

KITE.

To make what is called a six-cornered or house kite, take ⅛ in. stock and make two pieces 20 in. long x ⅜ in. wide, and one piece 16 in. long x ⅜ in. wide. In both ends of each stick, cut two notches crossing each other in the center. Place points 8 in. from one end of the 20 in. pieces, and in the middle of the 16 in. piece. Fasten them together by driving a ⅜ in. nail through the sticks at these points. Tie the sticks together where they cross, winding the twine around them a few times.

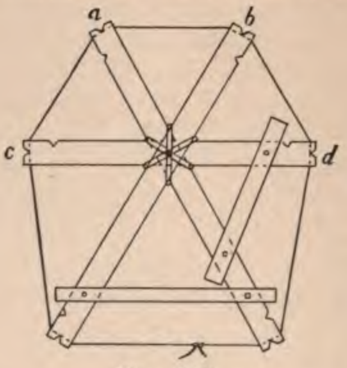


FIG. 303.

Cut notches in the edge of each stick ¼ in. from each end. Nail on temporarily two sticks to keep the two ends *a* and *b* 8 in. apart and to keep *c* and *d* equi-distant from *a* and *b*. Wind twine around the frame passing it through the notches in the ends and tie securely, and the work will appear as in Fig. 303.

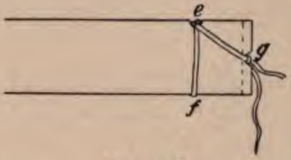


FIG. 304.

Tie a piece of twine 24 in. long around each end of each stick, as shown at *e f* Fig. 304, have the knot at *e*, bring the twine to *g* and tie, and leave a long end.

Cut a piece of paper ¾ in. larger than the frame. Fold the ¾ in. margin over the twine and fasten it with paste. Bring the loose twine at *a* Fig. 305 to *k* and tie it to the twine left there, keep it raised above the kite 3 or 4 in. by the board *i h*. Tie the twine at *b* to the twine at *j* in the same way. Tie the twine at *c* and *d* under the above cords and above the board,

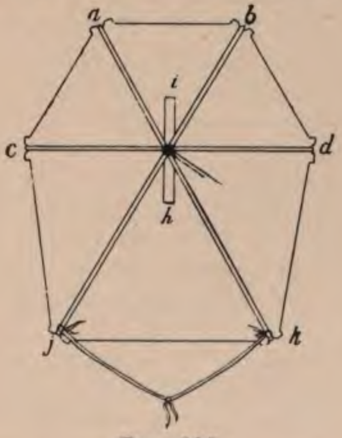


FIG. 305.

taking care to have the knot in the center. Bring the ends of twine *c* and *d* above the cords *a k*, and *b j*, and tie firmly and wind around vertically and tie again in a hard knot. (See Fig. 53). Tie these two ends to the ball of twine to be used in flying the kite. Be sure that the loose ends at *j* and *k* are of equal length, tie them in a knot about 6 in. below the kite, and to these ends fasten the tail and the work will appear as in Fig. 305.

Make the tail of strips of cotton cloth about 1 in. wide, tied together to a length of 20 ft. On the end should be a tassel of a dozen strips 8 or 10 in. long. The length of the tail should vary with the breeze. The knot where the flying twine is fastened may need to be retied at a lower point toward the tail, if the kite rises to a position so nearly vertical as to allow the wind to pass over it and cause it to fall. If the teacher prefers make only the frame in the schoolroom. Problem 82, Plate XVII, shows a kite in perspective.

LESSON LXXXIII.

WOODEN POST MODEL.

Take a block 8 in. x $\frac{7}{8}$ in. x $\frac{7}{8}$ in. Square pencil lines around it $\frac{1}{2}$ in., 2 in., 3 in. and 7 in. respectively from the left or lower end. Divide the spaces between the 2 in. and 3 in. lines, and between the 7 in. line and the top into four equal parts by squaring lines around the stick and the work will appear as in Fig. 306.

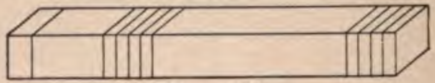


FIG. 306.

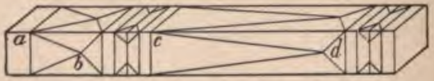


FIG. 307.

Draw oblique lines on each side as in Fig. 307 each of which makes an angle of 45° with the edge, excepting the lines *a b* and *c d*.

Cut away the corners to these lines. Problem 83, Plate XVII, shows a model of a wooden post.

LESSON LXXXIV.

STONE POST MODEL.

Take a block 5 in. x 1 ¾ in. x 1 ¾ in. Square around 2 in. from the left or lower end using the knife. Set the gauge 3-16 in., gauge from the squared line to the top on two opposite sides and cut to the lines. Gauge and cut in the same way the other two sides and the work will appear as in Fig. 308.

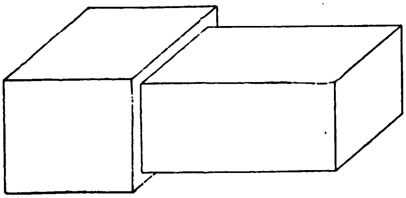


Fig. 308.

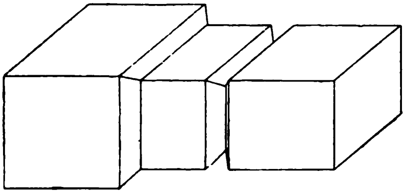


Fig. 309.

Square around 1 13-16 in. from the base using finely-pointed pencil and cut a bevel. Square around 3 in. and 3 ⅜ in. from the base and cut a V groove to these lines and the work will appear as in Fig. 309.

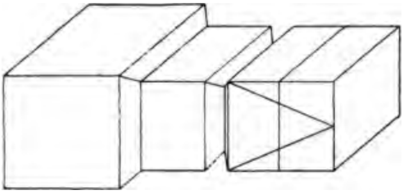


Fig. 310.

Square around ⅞ in. from the top and draw oblique lines on two opposite sides from the middle of the top to the V grooves as in Fig. 310.

Cut to the portions of these lines necessary to have the work appear as in Fig. 311.

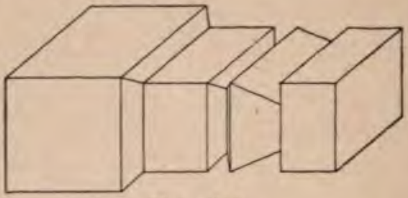


Fig. 311.

Draw oblique lines and cut the other two sides in the same way. Set the gauge 7-16 in. and make the top a cube. Make this cube a sphere as in Lesson LXIII. Problem 84, Plate XVII, shows a model of a stone post. This is a model of the stone posts on either side of the flight of steps at the entrance to the High School, Springfield, Mass. Let pupils make similar models of posts that can be found in their own city.

LESSON LXXXV.

THE HANDLE.

Take a block 8 in. x ⅞ in. x ⅞ in. Gauge and cut away one side making the piece ⅞ in. x ½ in. Square around with pencil 1 ¼ in. from one end and 2 in. from the other and draw freehand on two opposite sides the shape as in Fig. 312.

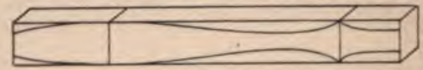


Fig. 312.

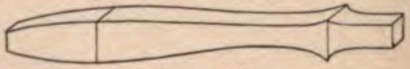


Fig. 313.

Cut straight across to these lines. Draw a similar shape on the edges and cut as before, and the work will appear as in

Fig. 313. A side or an edge view shows a handle shape, and the handle is every where rectangular in section.

To make this handle eight-sided in section, draw lines free-hand on each side, as though the handle were square to the side dimensions, and on each edge, as though it were square to the edge dimensions. Chamfer to these lines. In the same way make the handle sixteen-sided in section, and finish to an oval in section. Problem 85, Plate XVII, shows a handle in perspective.

LESSON LXXXVI.

THE CHAIN.

Take a block 3 ¾ in. x ⅞ in. x ⅞ in. Set the gauge 5-16 in. gauge two lines on each side and cut rabbits; and the work will appear as in Fig. 314.

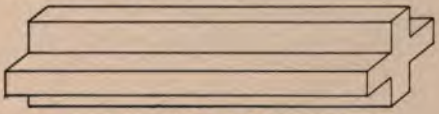


Fig. 314.

Cut ¼ in. groove across the middle of two opposite sides as in Fig. 315.

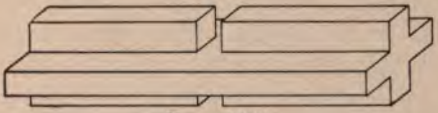


Fig. 315.

Cut similar grooves ¾ in. from each end on the alternate sides as in Fig. 316.

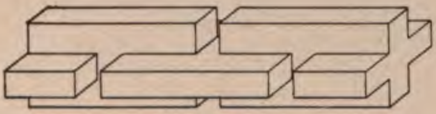


Fig. 316.

Round the corners and remove the partial links at each end and the work will appear as in Fig. 317.

Set dividers 3-16 in. and scribe lines as in Fig. 318.

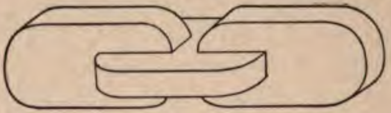


FIG. 317.

Cut out the shaded portions within the scribed lines and separate the links with the knife point, which makes a chain with links square in section. Make these links octagonal in section and then round. This will have to be done by the eye. Problem 86, Plate XVII, shows three links of a chain in perspective.

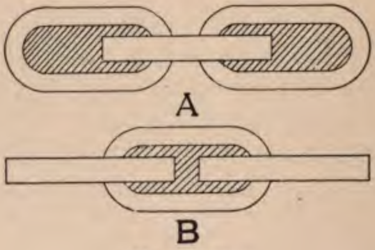


FIG. 318.

LESSON LXXXVII.

THE BOAT.

Take a block 7 ½ in. x 3 in. x 1 ½ in. Divide the length in five equal spaces and square around at each point of division,

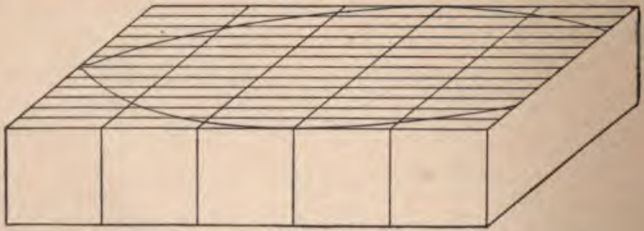


FIG. 319.

and draw lines lengthwise every ¼ in. on two opposite sides. Draw the plan of a boat on both sides, as in Fig. 319.

Cut straight across to the curved lines and redraw the squared lines on the cut edges, and the work will appear as in Fig. 320.

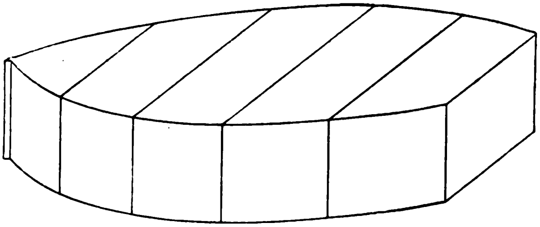


FIG. 320.

On the edges of the block draw lines ¼ in. from the top and ½ in. from each end, and draw the shape of the sides of the boat as in Fig. 321.

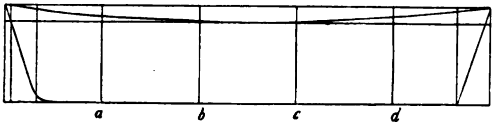


FIG. 321.

Cut to these lines, leaving the lengthwise line along the middle of the top 1-16 in. higher than the edges, and redraw the squared lines.

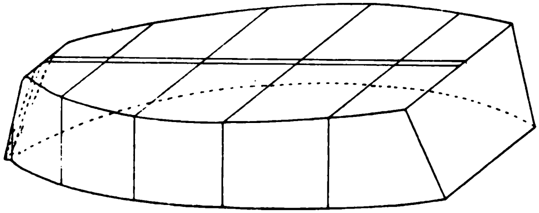


FIG. 322.

On the side of the block which is to be the bottom of the boat draw lengthwise lines 1-16 in. each side of the center for the keel, and similar lines on the front or bow, as in Fig. 322.

Draw on the rear or stern the shape shown at Fig. 323.

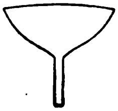


Fig. 323.

Take four pieces of ⅛ in. stock 1 ½ in. x 3 in. and draw lines each way at every ¼ in. With these lines for guides draw shapes as shown at A, B, C and D, Fig. 324. These are one-third size.

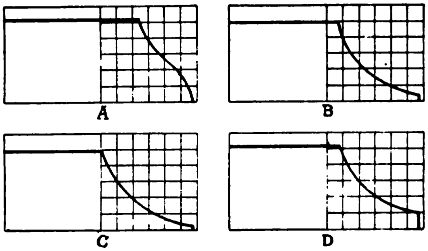


Fig. 324.

Cut to these four curved lines and use the boards as templets, their under edges agreeing with the under edge of the keel. First shape the block at its widest part, *c* Fig. 321, until it corresponds with the templet C, then shape it in the same way at *b* and *d*, then at *a*, and finally to the lines on the bow *and stern*, exercising taste and skill to make the outside form

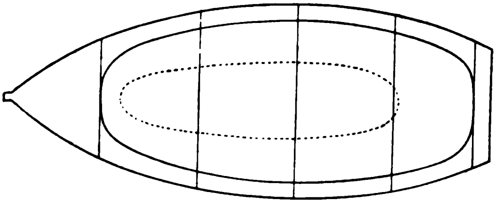


Fig. 325.

of the boat shapely at the points between these lines. Problem 87, Plate XVII, shows a perspective view of a boat. Any boy interested to hollow out the boat can provide himself with a ½ in. gauge and a ½ in. chisel to do the work. Draw the outline of the top as shown in Fig. 325.

Take three boards 3 in. x 2 in. x ⅛ in. and make the crosswise templets, as shown at B, C and D, Fig. 326.

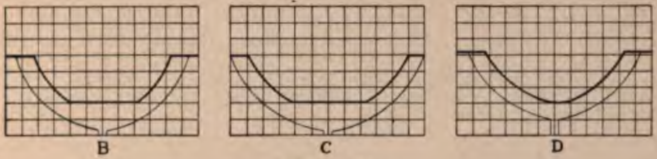


FIG. 326.

Cut away the lower portions of these boards to the heavily drawn lines. Shape the inside of the boat at the line *b* by means of the templet B, and so on. The shape of the inside of the boat along the middle lengthwise is shown in Fig. 327. The dotted line, Fig. 325, shows the outline of the floor.

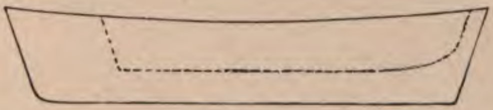


FIG. 327.

LESSON LXXXVIII.

THE PEN TRAY.

Fig. 328 shows three views of a pen tray, half size except the length, which should be 10 in. Use ⅜ in. and 5-16 in. stock and work from the drawing without further instructions.

Problem 88, Plate XVIII, shows a perspective view of a pen tray.

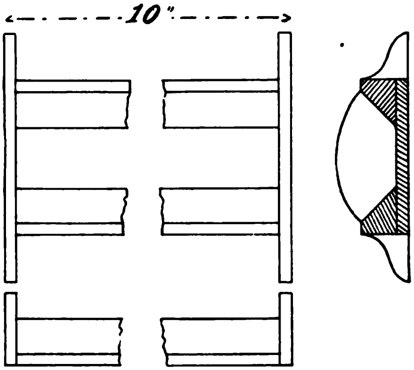


Fig. 328.

LESSON LXXXIX.

THE POSTAGE-STAMP BOX.

Fig. 329 shows two half sized views of a locked jointed box for holding stamps. In the front view the cover is raised for clearness of illustration. In the plan view the cover is removed. An oblique piece is put in on one side, for convenience in taking out the stamps. Problem 89, Plate XVIII, shows a perspective view of a postage-stamp box and cover.

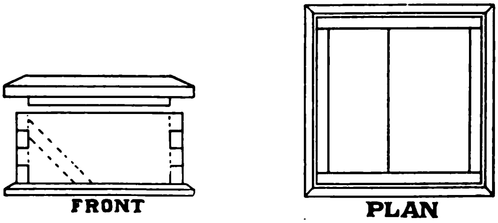


Fig. 329.

Other articles may be made from working drawings, and any pattern for scroll-sawing may be cut with the knife.

LESSON XC.

THE CUBE ROOT BLOCK AND BOX.

From $\frac{1}{8}$ in. stock make a locked jointed cubical box 2 $\frac{1}{2}$ in. on a side. From $\frac{1}{2}$ in. stock make three additions 2 $\frac{1}{2}$ in. square and three more additions 2 $\frac{1}{2}$ in. long x $\frac{1}{2}$ in. square; also a $\frac{1}{2}$ in. cube. To hold these make a cubical box from $\frac{3}{8}$ in. stock 3 $\frac{7}{8}$ in., outside measure. Make the bottom of $\frac{3}{8}$ in. stock and rabbit the frame for it. Problem 90, Plate XVIII, shows a perspective view of the blocks and box. It will be noticed that the cover slides in from the front.

LESSON XCI.

THE TUB.

Take a piece of $\frac{3}{8}$ in. stock about 3 $\frac{1}{4}$ in. square for the bottom board. Find the center as in Lesson XXXIX. Scribe on one side a circle 3 in. diameter and on the other side a circle 3 $\frac{1}{8}$ in. diameter. In each of these circles inscribe a twelve-sided polygon.

Cut a beveled edge to these lines, and the work will appear as in Fig. 330. A is a plan view and B is an edge view.

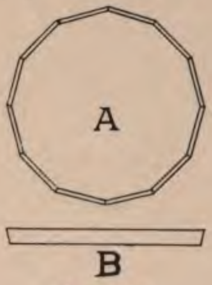


FIG. 330.

Make a similar piece 4 in. diameter on one side and 4 $\frac{1}{8}$ in. on the other, to be used for top piece in constructing the tub. Make twelve staves 3 in. long, one end of each being 1-16 in. wider than a face on the 4 in. top piece, and the other end 1-16 in. wider than a face on the bottom board, and bevel each edge

1-32 in. Nail with brads two staves to the bottom and construction piece, opposite each other, and two others half way between them, and the work will appear as in Fig. 331.

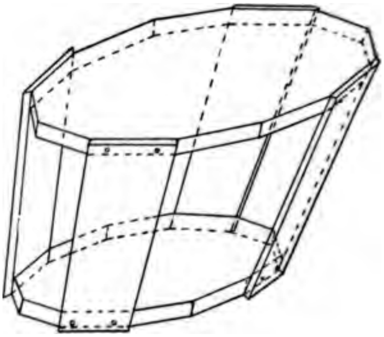


FIG. 331.

Nail the remainder of the staves, gluing them to the bottom and to each other. When the glue is dry cut off the tops of all the staves 1 in., except the two opposite ones. Cut these two ½ in. from the top and cut semicircular holes in them, making handles. Hoops may be made of stout paper. Problem 91, Plate XVIII, shows a perspective view of a tub.

LESSON XCII.

THE WHEELBARROW.

Fig. 332 shows two one-third sized views of a wheelbarrow.

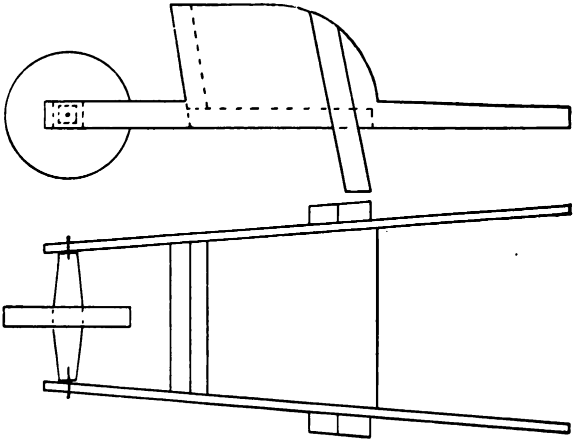


FIG. 332.

Make a side and handle in one piece of ⅛ in. stock, and the bottom, back, wheel and legs of 5-16 in. stock. Make the axle of ½ in. square stock, and cut the hole in the wheel to fit it. Nail the sides to the bottom and back with brads, and the legs to the sides as shown. Use ¾ in. No. 18, steel-wire brads for axle bearings.

Problem 92, Plate XVIII, shows a perspective view of a wheelbarrow.

LESSON XCIII.

THE APPLE.

Take a block 1 ¾ in. long x 2 ¼ in. square. Set the gauge ½ in., and following directions for the sphere make an oblate spheroid. Finish by cutting the depression in the top of the block, shaping the eye at the bottom and driving a nail for the stem. A sectional view of the work will appear as in Fig. 333.

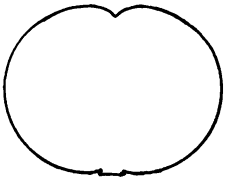


FIG. 333.

Problem 93, Plate XIX, shows a perspective view of an apple.

LESSON XCIV.

THE PEAR.

Take a block 2 ¾ in. long x 2 ¼ in. square. Make a pear templet of cardboard, drawing lines ½ in. and 1 in. from each end, as in Fig. 334.

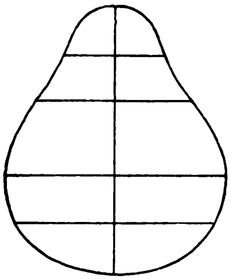


FIG. 334.

Follow the directions given for the ovoid or vase, and complete the pear by shaping the eye and driving a brad for the stem. If a natural pear can be obtained its irregularities may be copied. Problem 94, Plate XIX, shows a perspective view of a pear.

LESSON XCV.

THE PEACH.

Make a block 2 ½ in. x 2 ¼ in. x 2 ⅛ in. Center each end by gauging diameters. Make a templet to the top view of a peach, as in Fig. 335.

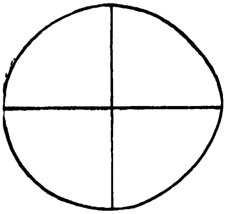


Fig. 335.

With this templet draw the shape on the ends of the block and cut straight across to the lines. Drive a ¾ in. brad half its length into the center of each end and draw a line on each side of the block joining the ends of the diameters gauged above.

Fig. 336 shows two adjacent side views of a peach.

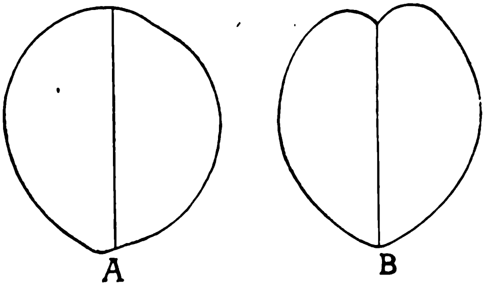


Fig. 336.

Make outside templets of ⅛ in. wood to fit the opposite sides of the view A, as in Fig. 337, and shape the narrow sides of the block from brad to brad to fit these templets. Make similar templets to fit opposite sides of the view B, and shape the wide sides of the block to them. Following previous instructions finish the peach, exercising taste and skill to make it shapely. Problem 95, Plate XIX, shows a perspective view of a peach.

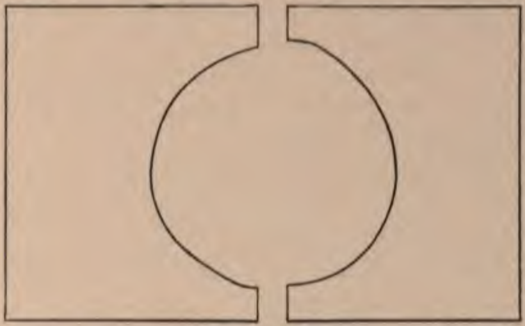


FIG. 337.

LESSON XCVI.

THE POTATO.

Let each pupil provide himself with a potato and make a model of it from a block 3 in. long x 2 ¼ in. square, following the directions given for the peach. When shaped, complete by cutting the eyes. Problem 96, Plate XIX, shows a perspective view of a potato.

LESSON XCVII.

THE LEMON.

Take a block 3 ½ in. long x 2 ¼ in. square. Let each pupil provide himself with a lemon and make a model of it, following the directions given for the peach. Problem 97, Plate XIX, shows a perspective view of a lemon.

LESSON XCVIII.

THE BANANA.

Provide each pupil with a banana and a block 7 ½ in. long x 1 ¾ in. square. Make cardboard templets of a top view and side view. Using the top templet draw the shape on two opposite sides and cut straight across to the lines; use the side templet on the remaining two sides and cut in the same way. Beginning midway of its length cut toward the ends and make the block to the shape of the banana, once more testing the taste and skill of the pupil. Problem 98, Plate XIX, shows a perspective view of a banana.

LESSON XCIX.

THE POD OF PEAS.

Take a block 3 $\frac{1}{4}$ in. x $\frac{5}{8}$ in. x $\frac{3}{8}$ in. Draw the side view on two opposite sides of the block, as in Fig. 338.

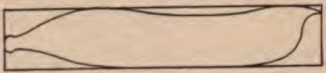


Fig. 338.

Cut straight across to these lines, then draw an edge view on the opposite edges, as in Fig. 339.

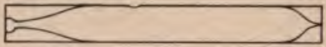


Fig. 339.

Cut to these lines. The block is now rectangular in section and must be made heart-shaped in section. It will be advantageous to have the natural pod to model from. Insert a bent pin or brad in the end for a stem. Problem 99, Plate XIX, shows a perspective view of a pod of peas.

LESSON C.

THE POD OF BEANS.

Fig. 340 shows two half-sized views of a pod of beans.

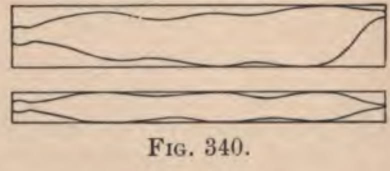


Fig. 340.

Make a block 4 in. x $\frac{5}{8}$ in. x 5-16 in. and following directions given for a pod of peas make a model of a pod of beans. Problem 100, Plate XIX, shows a perspective view of a pod of beans.

LESSON CI.

THE FRUIT TRAY.

To hold the fruit make a plain box like the one made at the close of the first year, or if desired make the more elaborate tray described below. From 5-16 in. stock make two pieces like A and two pieces like B., Fig. 341. This drawing is one-third size

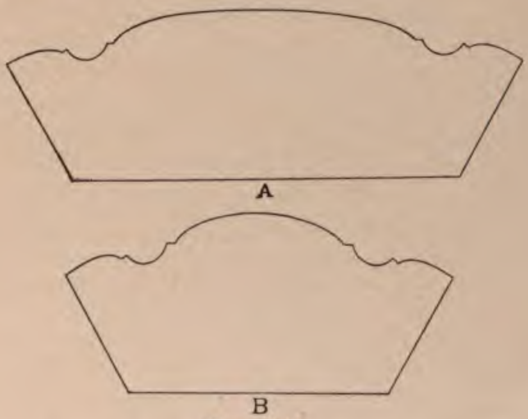


Fig. 341.

Mark an x on one side of each piece slightly, and use the marked side for the outside of the tray. Gauge a line 5-16 in. from the lower edge on the outside and bevel the edge. Miter the corners of the tray as follows: Using the miter bevel made in Lesson LXXIV, draw a line across each end of the beveled edge. From the end of each line gauge a line on the inside and bevel the end to this line, and an end piece will appear as in Fig. 342.

Nail the four pieces together, forming the body of the tray, using No. 18 steel-wire brads. Make the bottom of 5-16 in.

stock, ¾ in. longer and wider than the bottom of the body. Chamfer or round the upper corners of the bottom board and glue or nail it to the body. The attractiveness of the tray will be enhanced by some simple carving.

Problem 101, Plate XIX, shows a perspective view of a carved tray.

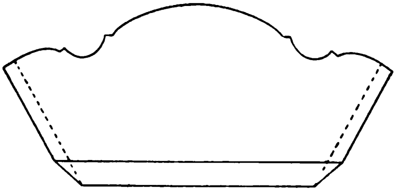
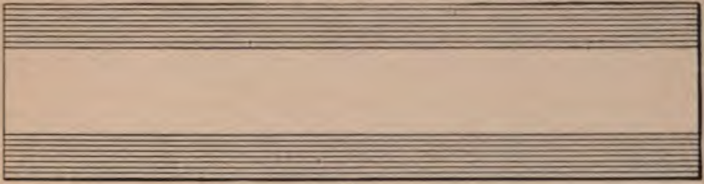


FIG. 342.

The entire course laid out in this book is not only adapted to pupils below the age of capacity for general tool-using, but will prove a source of special entertainment as well as manual instruction to adults, especially ladies, as the work can be done at home. The problems are for the most part fundamental and the work can be amplified at pleasure and without limit.

PLATE I.



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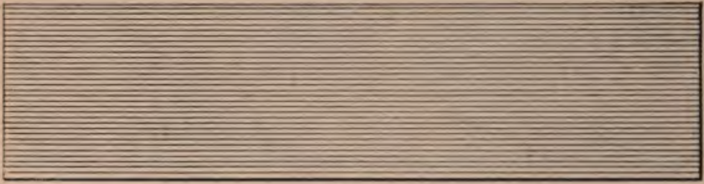

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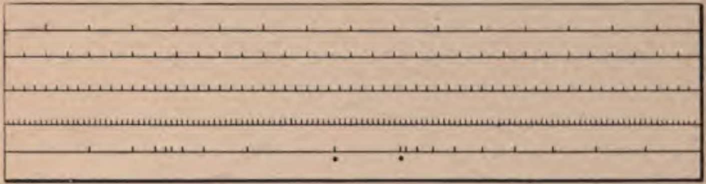

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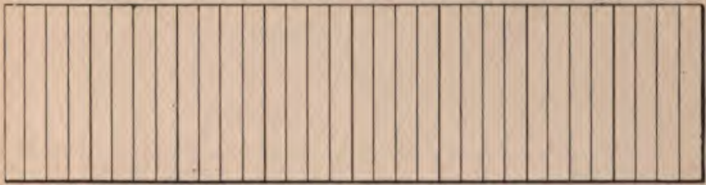

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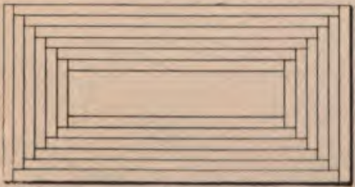

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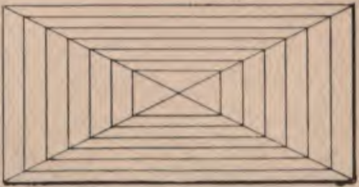

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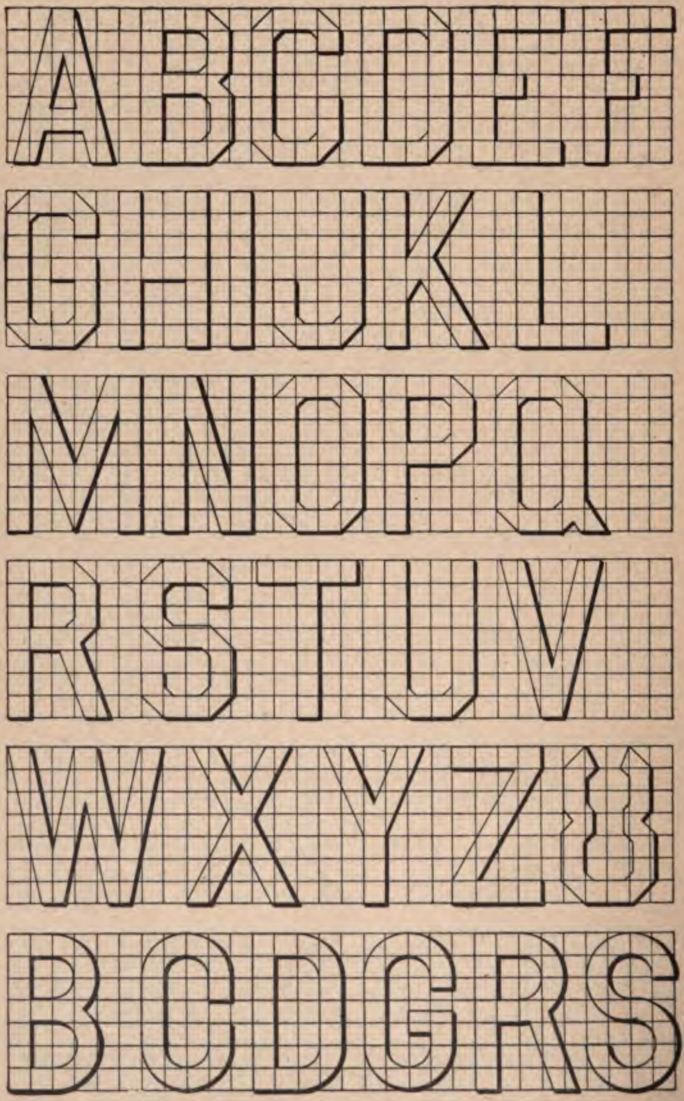

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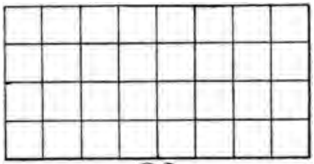

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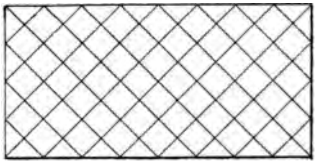

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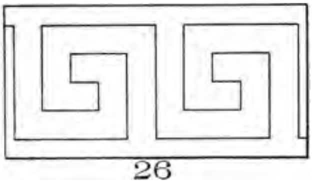

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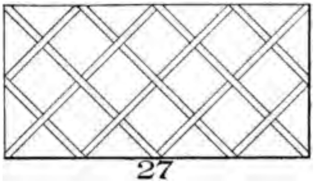

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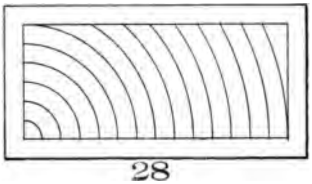

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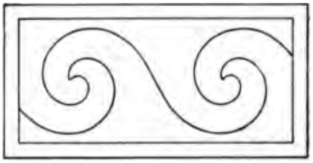

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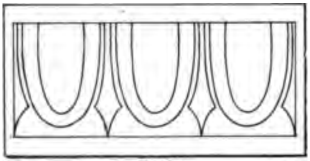

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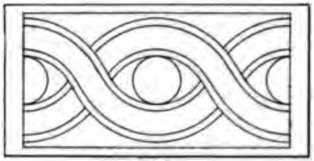

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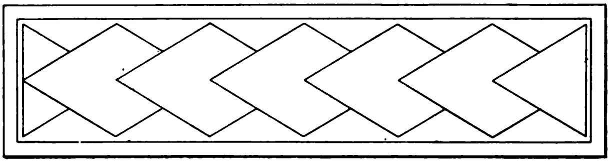

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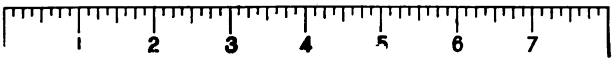

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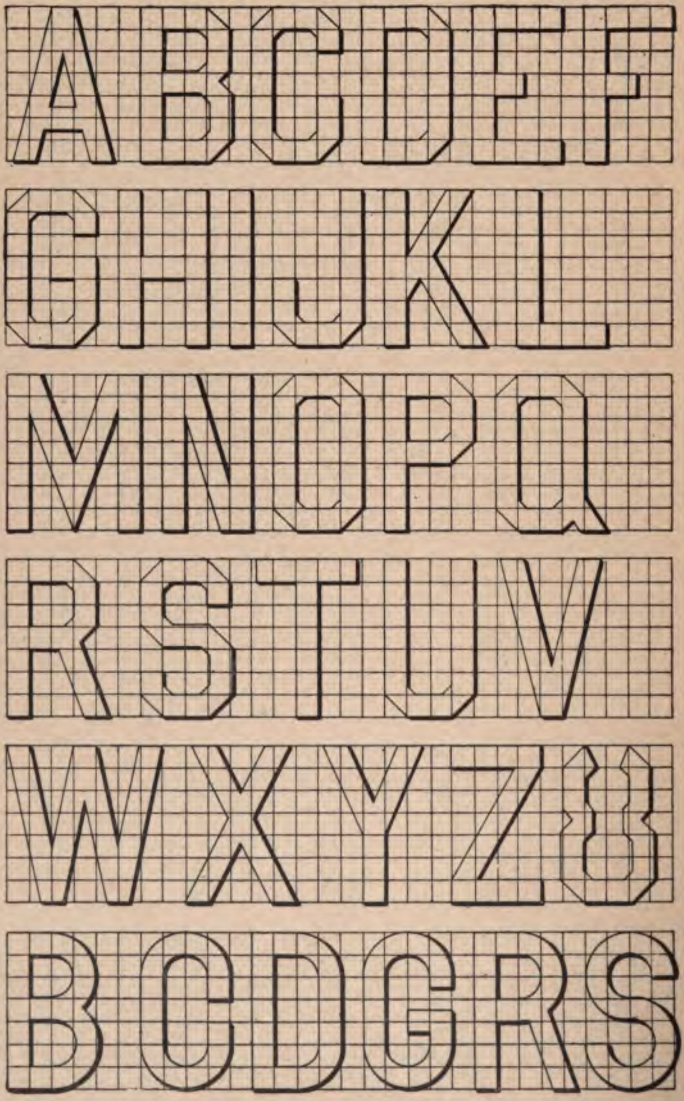

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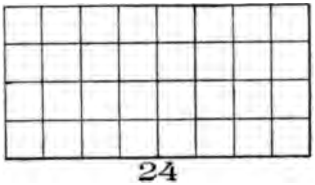
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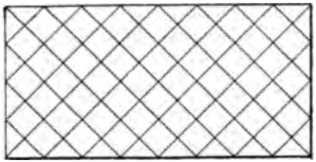
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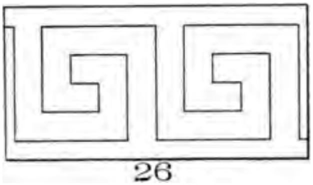
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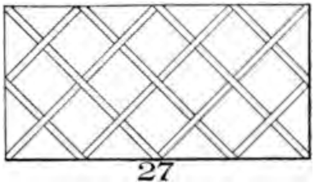
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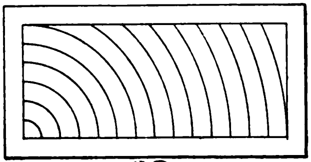
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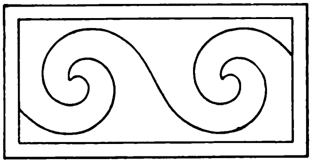
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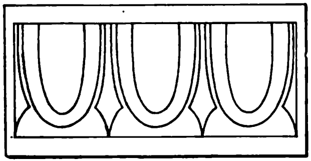
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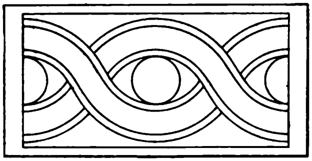
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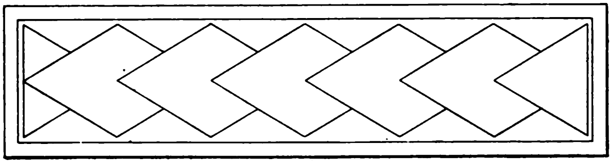
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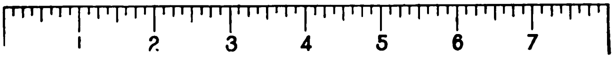

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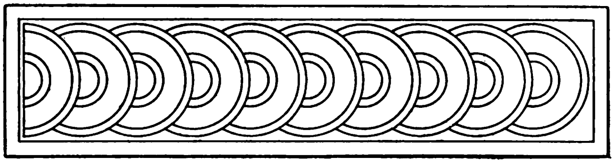

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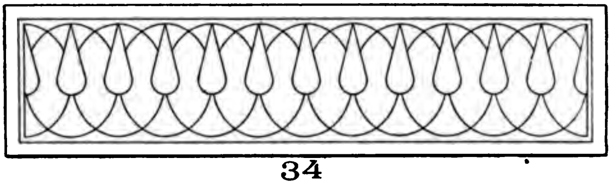

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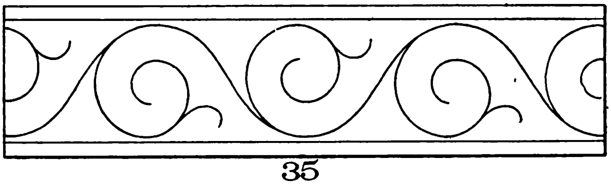

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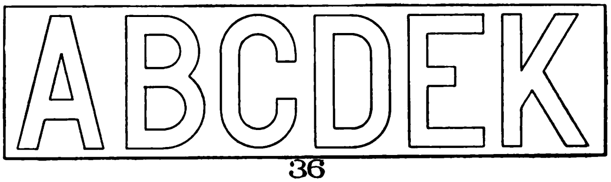

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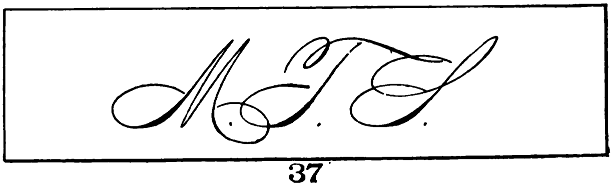

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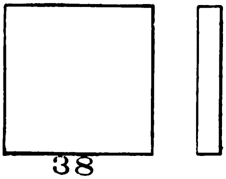

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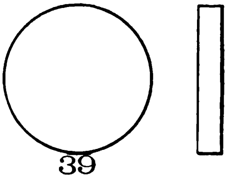

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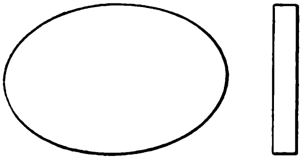

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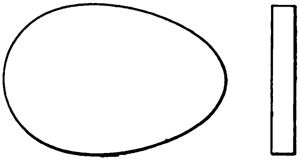

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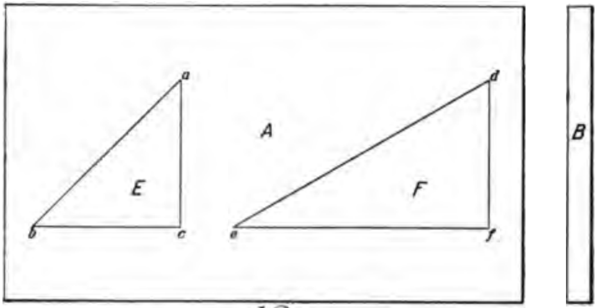

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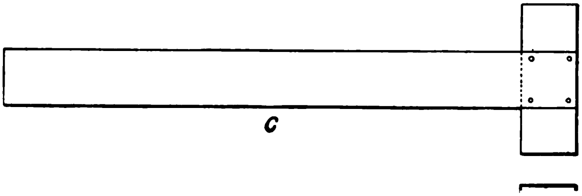

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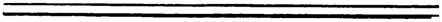

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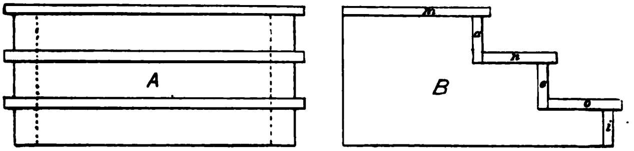

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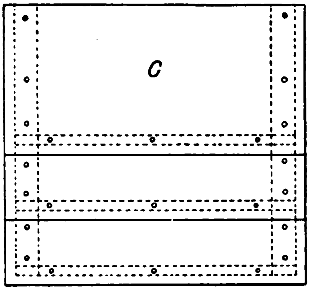

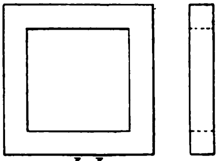

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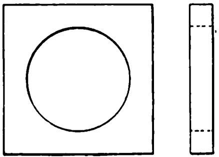

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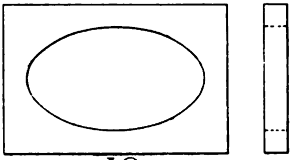

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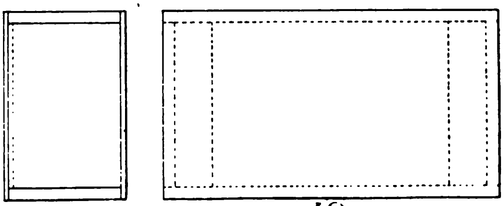

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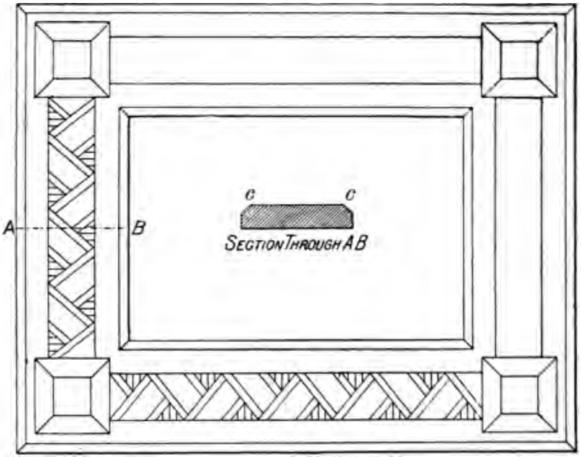

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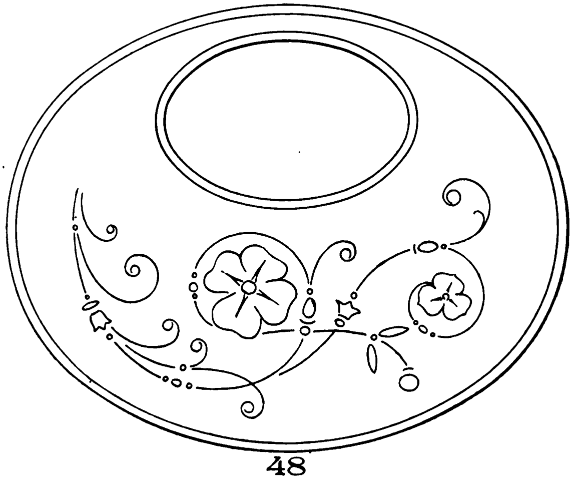

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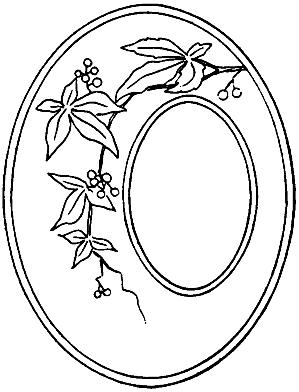

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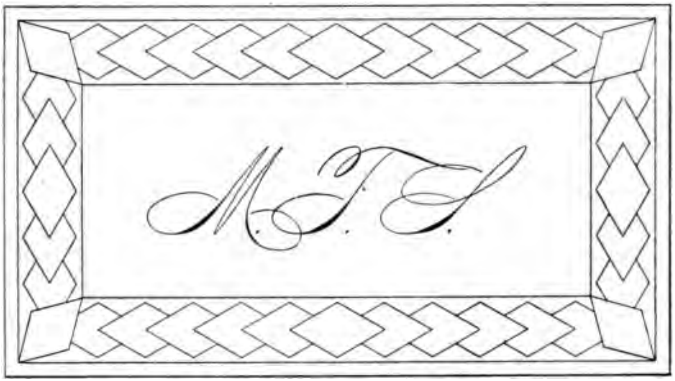

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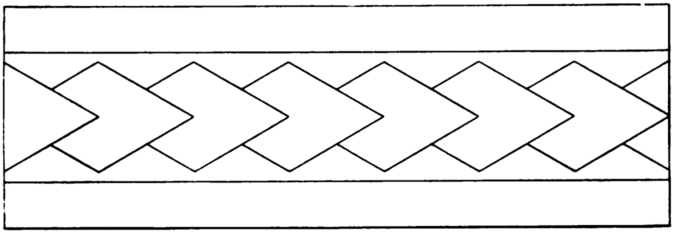

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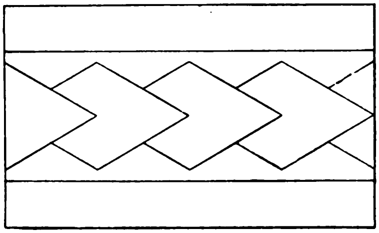

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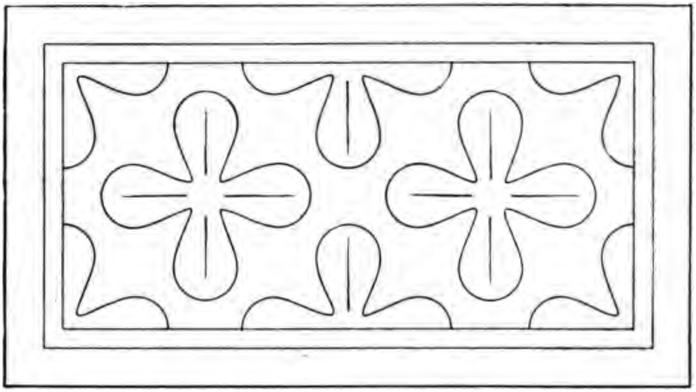

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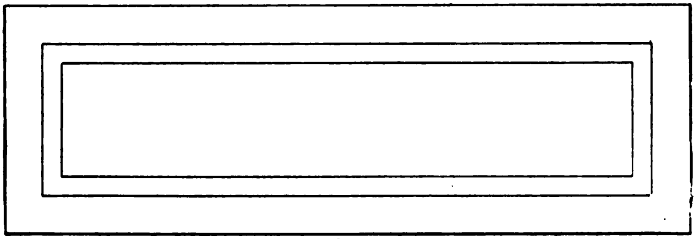

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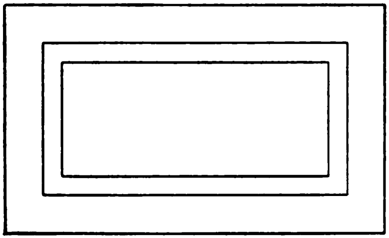

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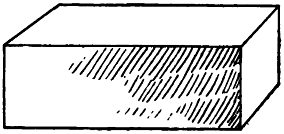
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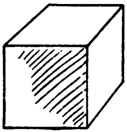
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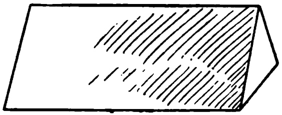
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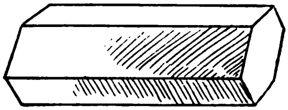
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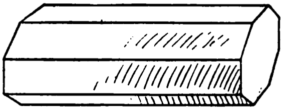
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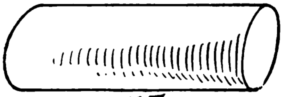
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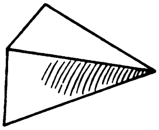
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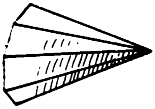
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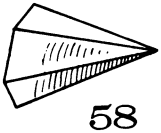
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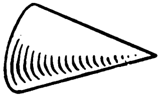
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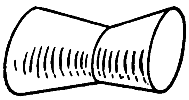
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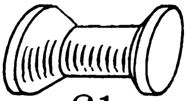
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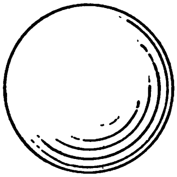

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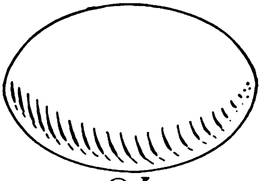

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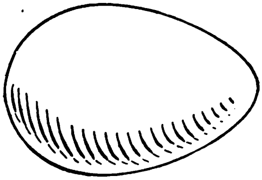

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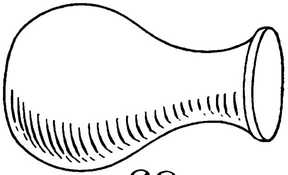

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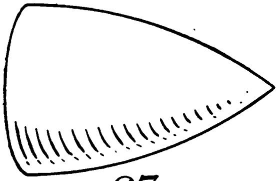

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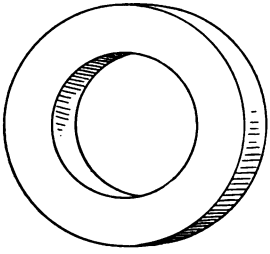

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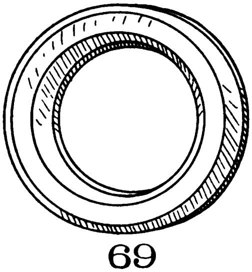

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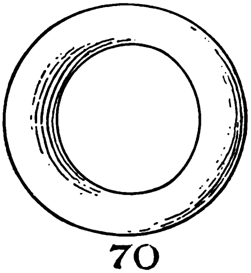

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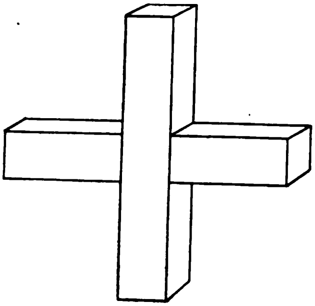

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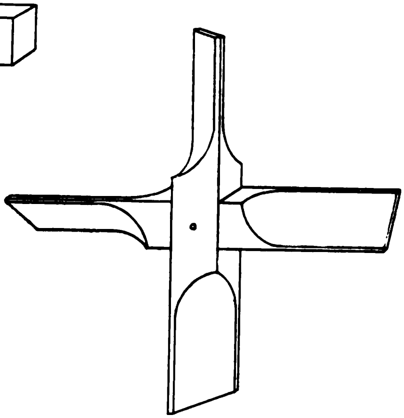

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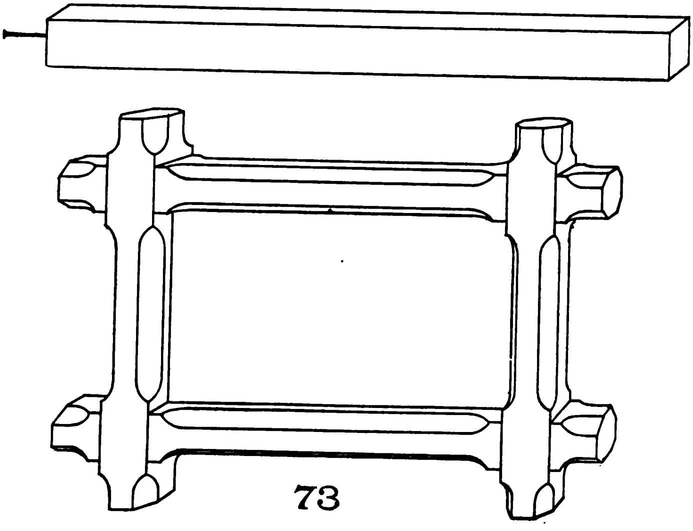

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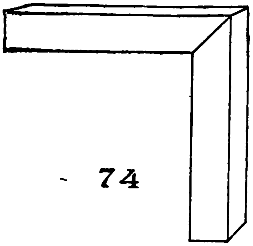

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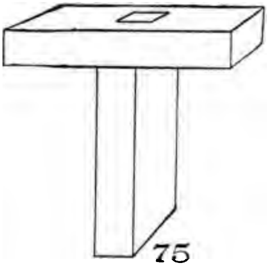

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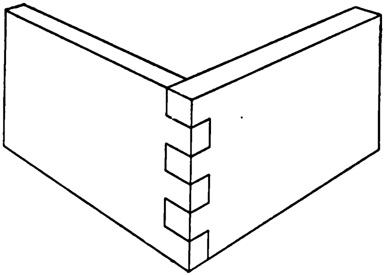

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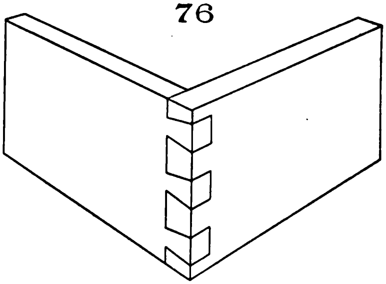

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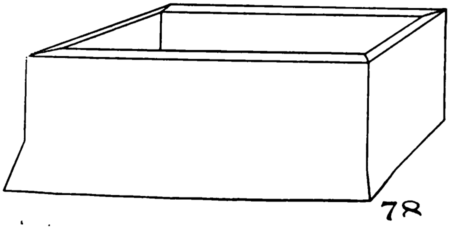

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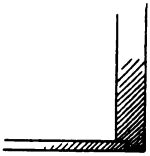

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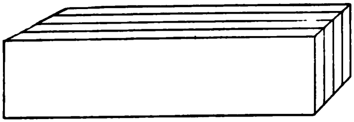

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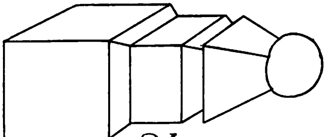

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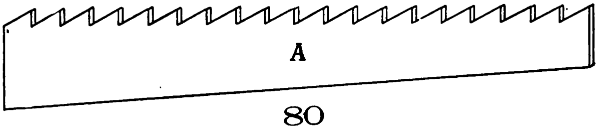

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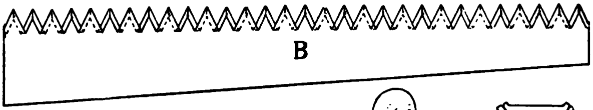

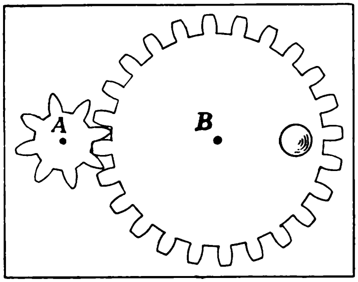

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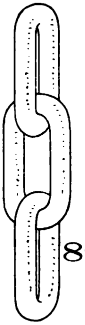

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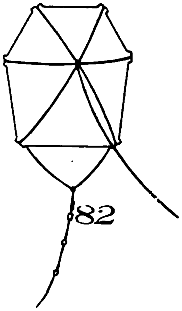

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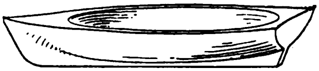

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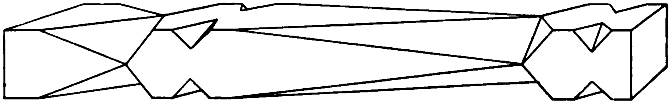

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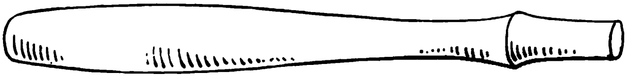

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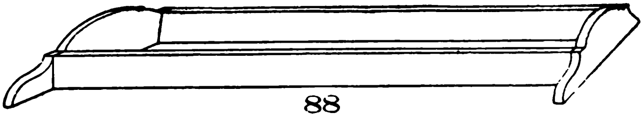

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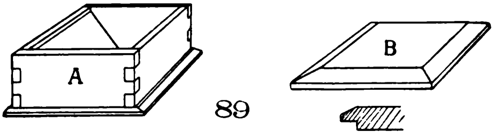

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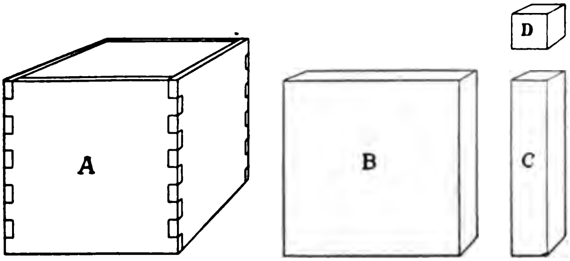

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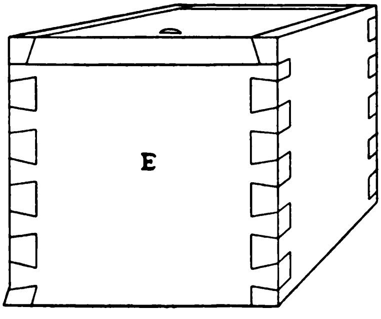

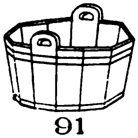

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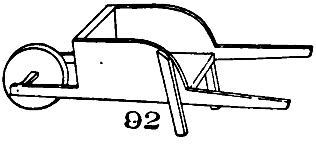

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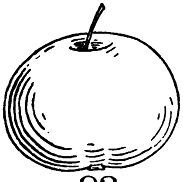
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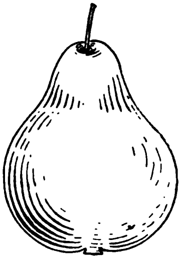
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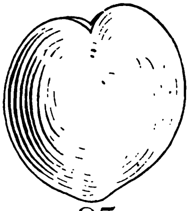
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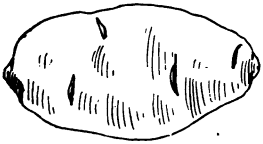
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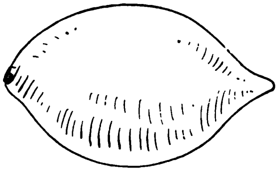
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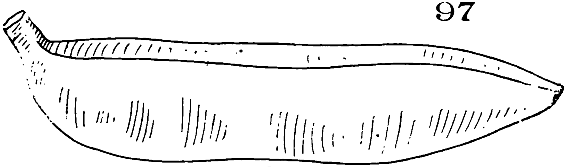
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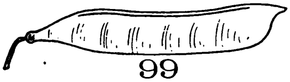
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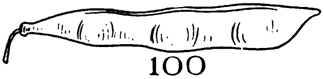
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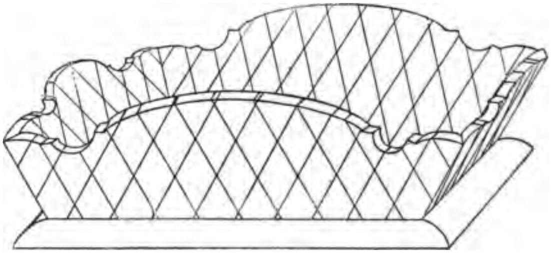
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